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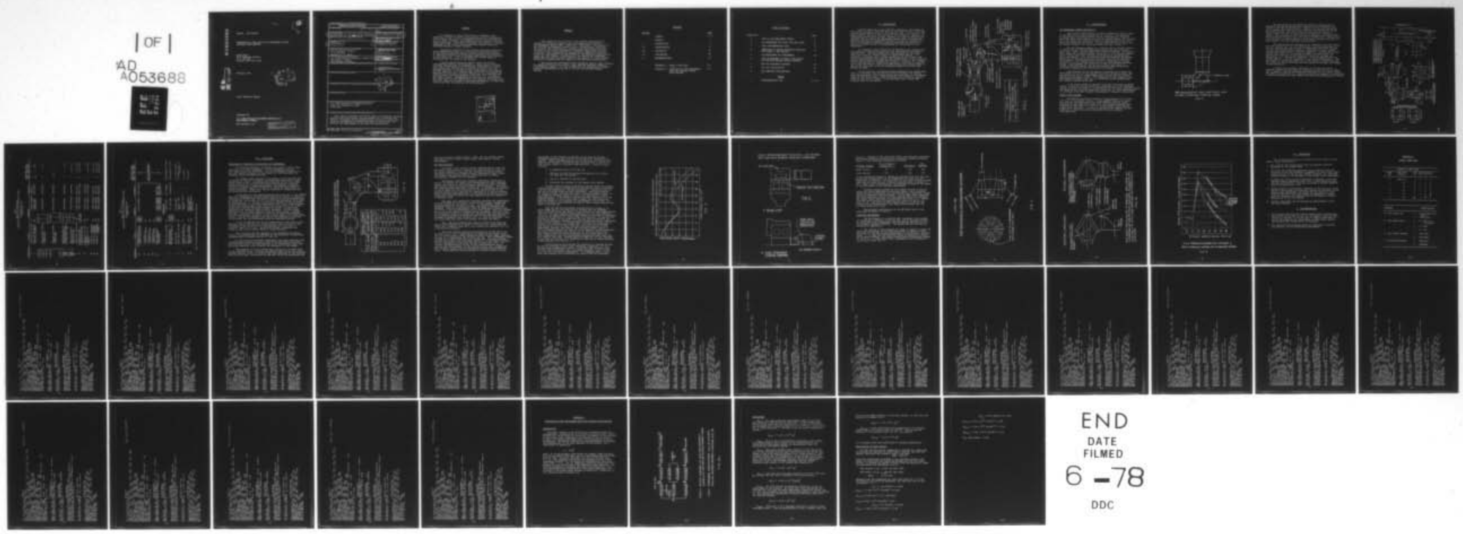

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PERFORMANCE OF THE LACV-30 AIR MANAGEMENT SYSTEM ORIGINAL CONFIGURATION

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Prepared For

U.S. ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMMAND

Fort Belvoir, VA

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This report describes the LACV-30 inlet Air Management System, presents test data showing the performance of its various components, recommends design modifications to provide higher pressures and incorporate an additional stage of filtration, and predicts the performance of the modified configuration.

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SUMMARY

In response to early indications of excessive sand ingestion through the LACV-30 main engines and low pressures at their inlets, the inlet Air Management System was instrumented for air flows, pressures and temperatures and tested at various power conditions. These tests confirmed the presence of negative pressures at the inlets and provided data showing where the principal pressure losses occurred.

Concurrent analysis of the original two-stage filtration system demonstrated that at its design filtration efficiency it would pass excessive amounts of particulates when operating in the high sand and dust environment experienced during testing at Fort Story, Va. It was concluded that a third stage of filtration must be added to the system.

Various modifications to reduce losses and further increase AMS pressures to accommodate a third stage of filtration were investigated. A modified AMS configuration incorporating additional filtration, a diffuser at the fan exit, an enlarged entrance to the engine inlet compartment, and shifting the oil cooler air load from the AMS fan to the lift system was designed and analyzed. Analysis showed that this configuration would provide a positive pressure of from 4" to 7" of water at the engine inlets. Recommendations were made for installation and early tests of key components in the original AMS aboard LACV-30-2 and, upon verification of expected performance, to fabricate, install and test the modified AMS configuration.

PREFACE

This report is one of a set of two reports documenting the results of a program to improve the performance of the LACV-30 Air Management System (AMS). Report No. 7467-928007, "Performance of the LACV-30 Air Management System Initial Configuration" describes the original AMS configuration, presents test data showing the performance of its various components, recommends design modifications to provide higher pressures and incorporate an additional stage of filtration, and predicts the performance of the modified configuration. Report No. 7467-928008, "Performance of the LACV-30 Air Management System Modified Configuration" presents the results of a test program conducted to demonstrate the adquacy of the AMS after modification.

The program was performed by Bell Aerospace Textron under Contract No. DAAK02-75-C-0149 with the U.S. Army Mobility Equipment Research & Development Command. Mr. John Sargent was the Contracting Officer's Technical Representative and Mr. C. E. Burr was the BAT Program Manager.

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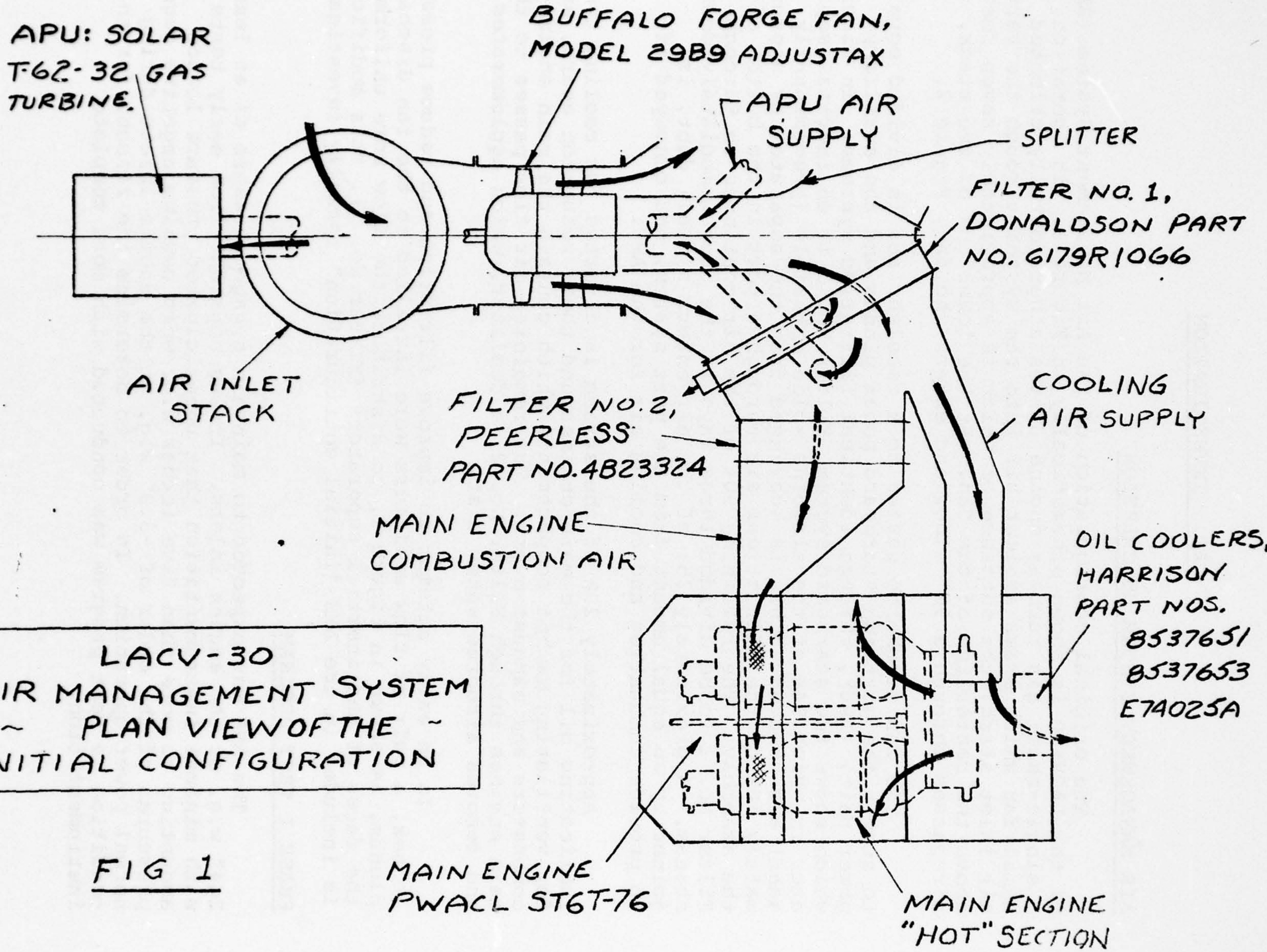
I. INTRODUCTION

Initial operation of the LACV-30-1 vehicle on the beaches of Fort Story, Virginia, revealed that the main engine first stage compressor blades were wearing at an excessive rate. The nature of the wear, shown in Figure 1, was typical of that caused by ingestion of abrasive particles such as sand. However, the LACV-30 vehicles are equipped with an active Air Management System (AMS) incorporating moisture and particle separation devices to clean the incoming air, and a fan designed to maintain positive pressures throughout the system to prevent inflow of contaminated air downstream of the separators.

In response to the indications of excessive sand ingestion by the engines, a preliminary survey of key AMS pressures was made in February 1976. The data showed that the pressures at the engine inlet were actually several inches of water below ambient. In addition to allowing sand to enter downstream of the filters, the low system pressures also impaired the effectiveness of the engine oil cooler, which required pressurized cooling air from the AMS. Several minor modifications to increase AMS pressure, including an improved lip at the AMS intake, higher fan blade angles, and turning vanes in the intake elbow and in the fan discharge plenum were tried with minimal success.

In the meantime, calculations were performed which showed that even at the design value of AMS filtration efficiency the engines would see excessive inlet contamination when operating in the extreme sand and dust environment, often producing zero visibility, experienced at Fort Story. Hence, it was concluded that a major AMS redesign must be considered.



LACV-30
AIR MANAGEMENT SYSTEM
~ PLAN VIEW OF THE ~
INITIAL CONFIGURATION

FIG 1

II. INVESTIGATION

AIR MANAGEMENT SYSTEM DESCRIPTION

The original configuration of the Air Management System (AMS) of the LACV-30 is shown schematically in Figure 1. In operation, a single-shaft gas turbine engine drives a horizontally oriented axial fan which draws ambient air into the system through the vertical air inlet stack, the entrance of which is approximately seven feet above the centerline of the fan. At the lower end of the stack, the air passes through a 90^{o} elbow and enters the fan, Figure 2.

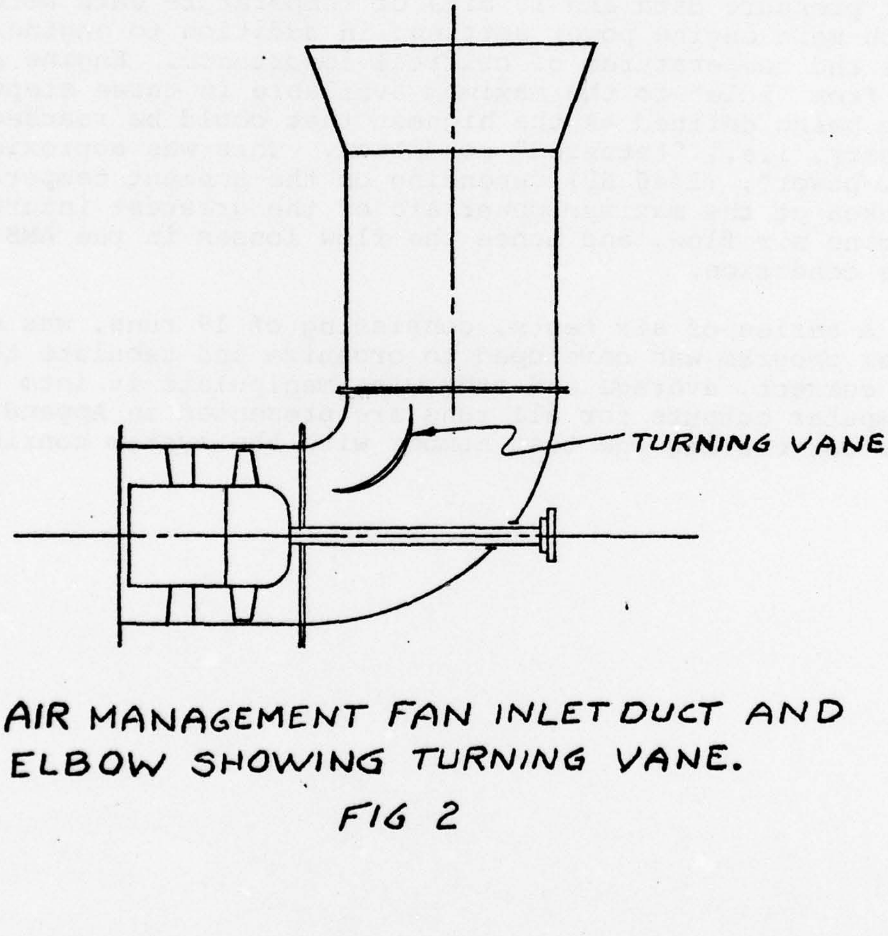
The fan discharge passes to a receiver and is divided equally to supply the port and starboard power plants and the auxiliary power unit, (APU), through identical filtration systems. In Figure 1, which shows the starboard system, Filter No. 1 is an inertial separator in which 94% of the airborne solid materials (predominantly sand) are removed. This is scavenged from the separator by approximately 10% of the main stream air through a port in the bottom of the assembly. The remaining 90% of the air continues on through Filter No. 1 to be divided three ways in the duct immediately downstream. Approximately 25% of the air enters a small duct, is joined by an equal amount from the port system, and conveyed aft to provide combustion and cooling air for the APU.

Approximately 20% of the stream is diverted for cooling the lubricating oil for the main engines and their reduction gears, and for ventilating the hot compartments which contain the main engine combustors and exhaust ducts. The remaining air flow passes to the main engines through Filter No. 2, a demister, which agglomerates and removes airborne water mist.

In an early attempt to improve filtration and reduce pressure losses, a pair of flow splitters were installed in the fan discharge plenum, as shown in Figure 1, to distribute the flow more uniformly across the faces of the inertial separators (Filter No. 1). This modification is included in the AMS "initial configuration" formally investigated.

PHASE I TEST PROGRAM

The AMS was expected to maintain a gage pressure of at least 2.4" w.g. at the engine inlets. It was apparent from early tests with minimal instrumentation that unanticipated pressure losses amounting to more than five inches w.g. were causing negative gage pressures of the order of -3.0" w.g. at the engine inlets during normal power operation. In order to determine the reasons for this condition a test program was conducted with more complete instrumentation.



AIR MANAGEMENT FAN INLET DUCT AND ELBOW SHOWING TURNING VANE.

FIG 2

The test plan for this phase was directed specifically at assessing the AMS performance and identifying the components that failed to perform as anticipated. Figure 3 is the instrumentation plan, showing the locations of the pressure and temperature probes. The identification code associated with each sensor appears in Table I where the type of probe and its purpose are indicated. In general, the objective of the plan was to determine the temperatures, static pressure distributions, and velocity heads (where significant), to facilitate the determination of flow rates, pressure drop and, in some regions, the local pressure distributions.

The test matrix was arranged to be compatible with the vehicle, the time schedule and the test objectives. Briefly summarized, 52 bits of pressure data and 10 bits of temperature data were recorded for each main engine power setting, in addition to engine speeds, torques and temperatures of critical importance. Engine powers were varied from "idle" to the maximum available in three steps, the maximum being defined as the highest that could be reached in a stationary, i.e., "tethered" condition. This was approximately the "normal power", (1440 HP) depending on the ambient temperature. The data taken at the maximum power are of the greatest interest because the engine air flow, and hence the flow losses in the AMS, are largest at this condition.

A series of six tests, consisting of 19 runs, was made. A computer program was developed to organize and tabulate the raw data, and to correct, average and otherwise manipulate it into useful forms. The computer outputs for all runs are presented in Appendix A, along with a table correlating the test number with the system configuration tested.

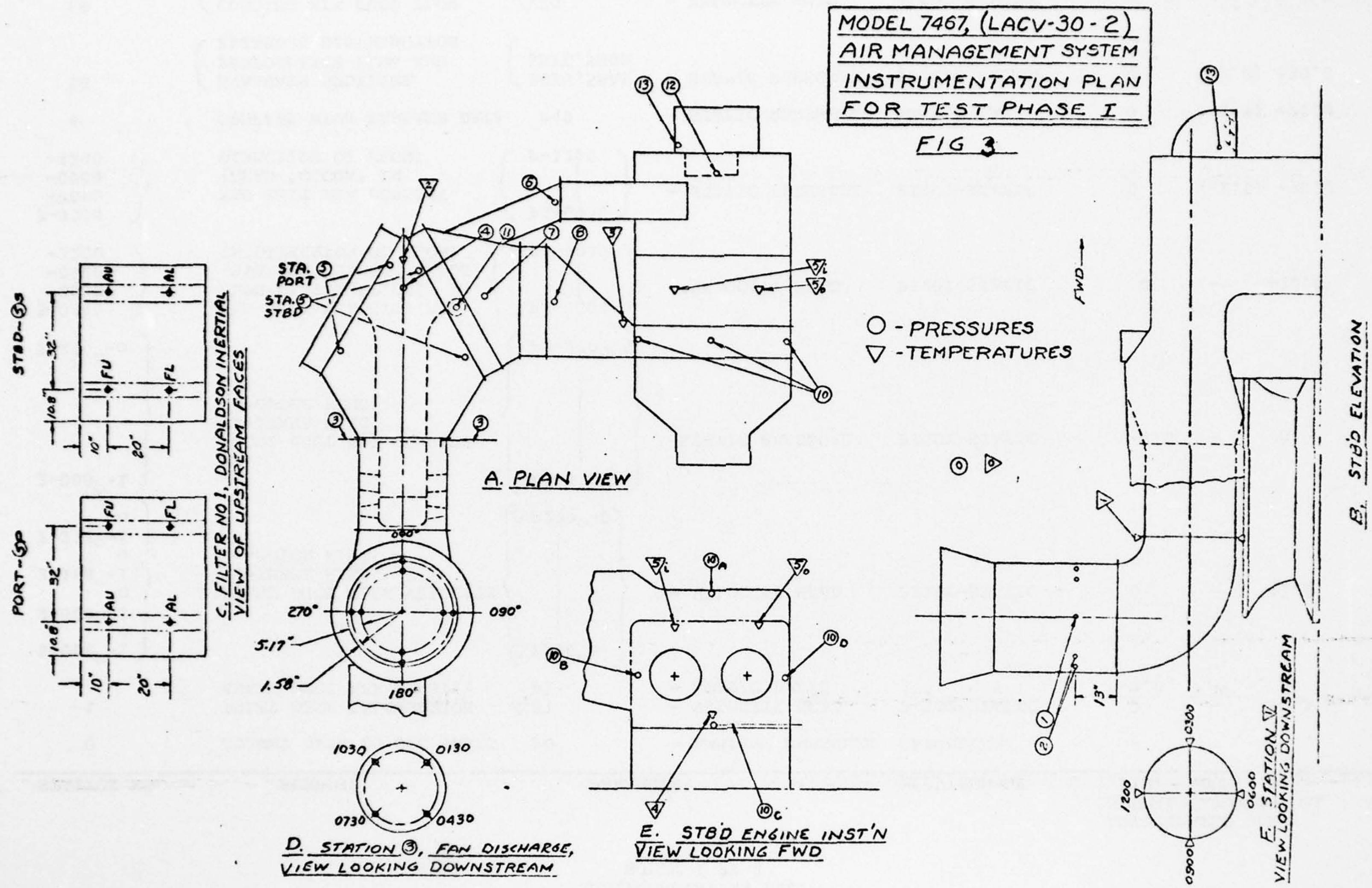

MODEL 7467, (LACV-30-2)
AIR MANAGEMENT SYSTEM
INSTRUMENTATION PLAN
FOR TEST PHASE I
FIG 3
○ - PRESSURES
▽ - TEMPERATURES
FWD
A. PLAN VIEW
B. STB'D ELEVATION
C. FILTER NO 1, DONALDSON INERTIAL
VIEW OF UPSTREAM FACES
STBD-⑤s
PORT-⑤p
D. STATION ③, FAN DISCHARGE,
VIEW LOOKING DOWNSTREAM
E. STB'D ENGINE INST'N
VIEW LOOKING FWD
F. STATION ⑪
VIEW LOOKING DOWNSTREAM
STA. ⑤ PORT
STA. ⑤ STBD
270°
090°
180°
5.17"
1.58"
1030
0130
0730
0430
1200
0300
0600
0900
13"
32"
10.8"
10"
20"
AU
AL
FU
FL

TABLE I

MODEL 6467 (LACV-30-2)
PERFORMANCE TESTS OF THE AIR MANAGEMENT SYSTEM

INSTRUMENTATION LIST
SJEET 1 PF 2

STATION NO.	PURPOSE	PARAMETER		ACQUIRED BY	ANTICIPATED RANGE NORMAL MIN.	(APU) (OUT)	NORMAL MAX.
0	ADJUST DATA TO STD BASIS	PO	- AMBIENT PRESSURE	BAROMETER	-	-	-
1	INLET DUCT CALIBRATION	ΔP1	- VELOCITY HEAD	PITOT-STATIC	0	-	+1.5
	INLET DUCT AIR DENSITY	P1	- STATIC PRESS	" "	-2.0	-	0
2-000°-i o 2-000°-i o 2-180°-i o 2-270°-i o	INLET DUCT FLOW VELOCITY (i=INNER RING, o=OUTER RING)	ΔP000°L | ΔP270°-0	- VELOCITY HEAD	PITOT-STATIC	0	-	+1.5
2-000°-i 2-270°-o	INLET DUCT AIR DENSITY (i=INNER RING, o=OUTER RING)	P2-000°L | P2-270°-0	-STATIC PRESSURE	PITOT-STATIC	-2.0	-	0
3-0300 -0600 -0900 -1200	FAN EXIT VELOCITY AND FLOW DISTRIBUTION. (STATION "CLOCK" READS IN DIRECTION OF FLOW)	ΔP3-0300 | ΔP3-1200	- VELOCITY HEAD	PITOT-STATIC	0	-	+10.0
3-0300 -0600 -0900 -1200	FAN EXIT AIR DENSITY (READ "CLOCK" IN DIRECTION OF FLOW)	P3-0300 | P-1200	- STATIC PRESSURE	PITOT-STATIC	0	(-2.5)	+20.0
4	COMPARE WITH EARLIER DATA	P45	- STATIC PRESSURE	STATIC TAP	0	(-2.5)	+20.0
5S	EVALUATE SPLITTER PERFORMANCE FLOW AND PRESSURE DISTRIBUTION	5SFU,5SAU 5SFL,5SAL	- STATIC PRESSURE	STATIC PICKUP	0	(-2.0)	+20.0
6S	COOLING AIR DUCT FLOW VELOCITY	ΔPG	- VELOCITY HEAD	PITOT-STATIC	0	-	+ 1.0
	COOLING AIR DUCT AIR DENSITY	PG	- STATIC PRESSURE	PITOT-STATIC	0	(-6.0)	+20.0
7S	FILTER #1, P.(DONALDSON INERTIAL)	P75	- STATIC PRESSURE	STATIC TAP	0	(-6.0)	+20.0
8S	FILTERS #2,P,(PEERLESS DEMISTER)	P85	- STATIC PRESSURE	STATIC TAP	0	(-8.0)	+18.0
9S	FILTERS #3, P,(DONALDSON BARRIER	P95	- STATIC PRESSURE	STATIC TAP	0	(-10.0)	+26.0

TABLE I

MODEL 7467 (LACV-30-2)
PERFORMANCE TESTS OF THE AIR MANAGEMENT SYSTEM

INSTRUMENTATION LIST
SHEET 2 OF 2

STATION NO.	PURPOSE	PARAMETER		ACQUIRED BY	ANTICIPATED RANGE NORMAL (APU) NORMAL MIN. (OUT) MAX.
5P	EVALUATE SPLITTER PERFORMANCE, FLOW AND PRESSURE DISTRIBUTION	P5PFU P5PFL P5PAU P5PAL	- STATIC PRESSURE	STATIC PICKUP	SAME AS CORRESPONDING STARBOARD STATIONS
7P	P FILTER NO. 1, (DONALDSON INERTIAL)	P7P			
8P	P FILTER NO. 2, (PEERLESS DEMISTER)	P8P			
9P*	P FILTER NO. 3, (DONALDSON BARRIER)	P9P			
10P	ENGINE INLET PLENUM STATIC PRESSURE DISTRIBUTION	P10PA	- STATIC PRESSURE	STATIC TAP	
		P10PB	- STATIC PRESSURE	STATIC TAP	
		P10PC	- STATIC PRESSURE	STATIC PROBE	
		P10PD	- STATIC PRESSURE	STATIC TAP	
			TEMPERATURES		
	ADJUST DATA TO STD BASE	TO	- AMBIENT TEMP.	LAB. THERMOM.	LOCAL AMBIENT, 0°-110°F
1	FAN INLET MACH NO. EXHAUST INGESTION FAN INLET AIR DENSITY	T1-1200 T1-0300 T1-0600 T1-0900	- FAN INLET TEMP.	CU CONSTATAN TC	LOCAL AMBIENT, 0-110°F
2	FAN EFFICIENCY	T2	- FAN EXIT TEMP.	" "	T1 + (6° TO 20°) (F)
3	ADJUST POWER TO STD BASE	T3	- MAIN ENG. INLET TEMP.	" "	T2 (NORMAL), TO + 30° (APU OUT)
4	MONITOR FOR WARM AIR LEAKAGE AND COMP. BLEED AIR	T4	- ENG. INLET AIR IN PLENUM	" "	T1 + 100° (F)
5I	MONITOR ENG. COMBUSTOR "HOT" SECTION COOLING EFFICACY	T5I	INBOARD COMBUSTOR SPACE TEMP.	" "	T2 TO 400°F
5O		T5O	OUTBOARD COMBUSTOR SPACE TEMP.		

*NO. 9 TO BE ACTIVATED WHEN BARRIER FILTER IS INSTALLED.

III. DISCUSSION

COMPARISON OF PREDICTED AND MEASURED AMS PERFORMANCE

The expected pressures throughout the original AMS had been predicted for a 3200 horsepower, or 1600 horsepower per Twin Pac, engine operating condition. The high horsepower condition is the most critical because the high engine air flow maximizes the pressure losses throughout the AMS.

The highest power achieved in the Phase I tests was the 1385 horsepower of Test No. 6-C3b0616, performed with the LACV-30 under way at about 30 mph. Although partial recovery of the free stream dynamic pressure in the AMS inlet stack could present a slightly optimistic picture of system performance, the maximum theoretical value of recovered pressure is about 0.5 inches of water, which is deemed negligible. Thus, that run was selected for comparison with the predicted AMS performance.

A tabulation of key system pressures from Test No. 6, Run C3b0616 with the corresponding original design prediction appears in Figure 4. These data indicated that the static pressure, P5 at the upstream face of Filter No. 1 was lower by 2.9" w.g. than was predicted. This could be attributed to: 1) failure of the fan to produce its design value of pressure head, 2) fan inlet disturbances due to the close proximity of the inlet stack elbow to the front face of the fan, or 3) to the inability of the fan discharge receiver to convert a significant portion of the discharge head to static pressure. Of these three possibilities, the first appeared to be the least likely. Further, Test Nos. 3 and 4 showed there is little to be gained by resetting the fan blade angles. However, if the turning vane in the inlet elbow, Figure 2, failed to suppress sufficiently the formation of vortices in the elbow, the fan performance could be adversely effected.

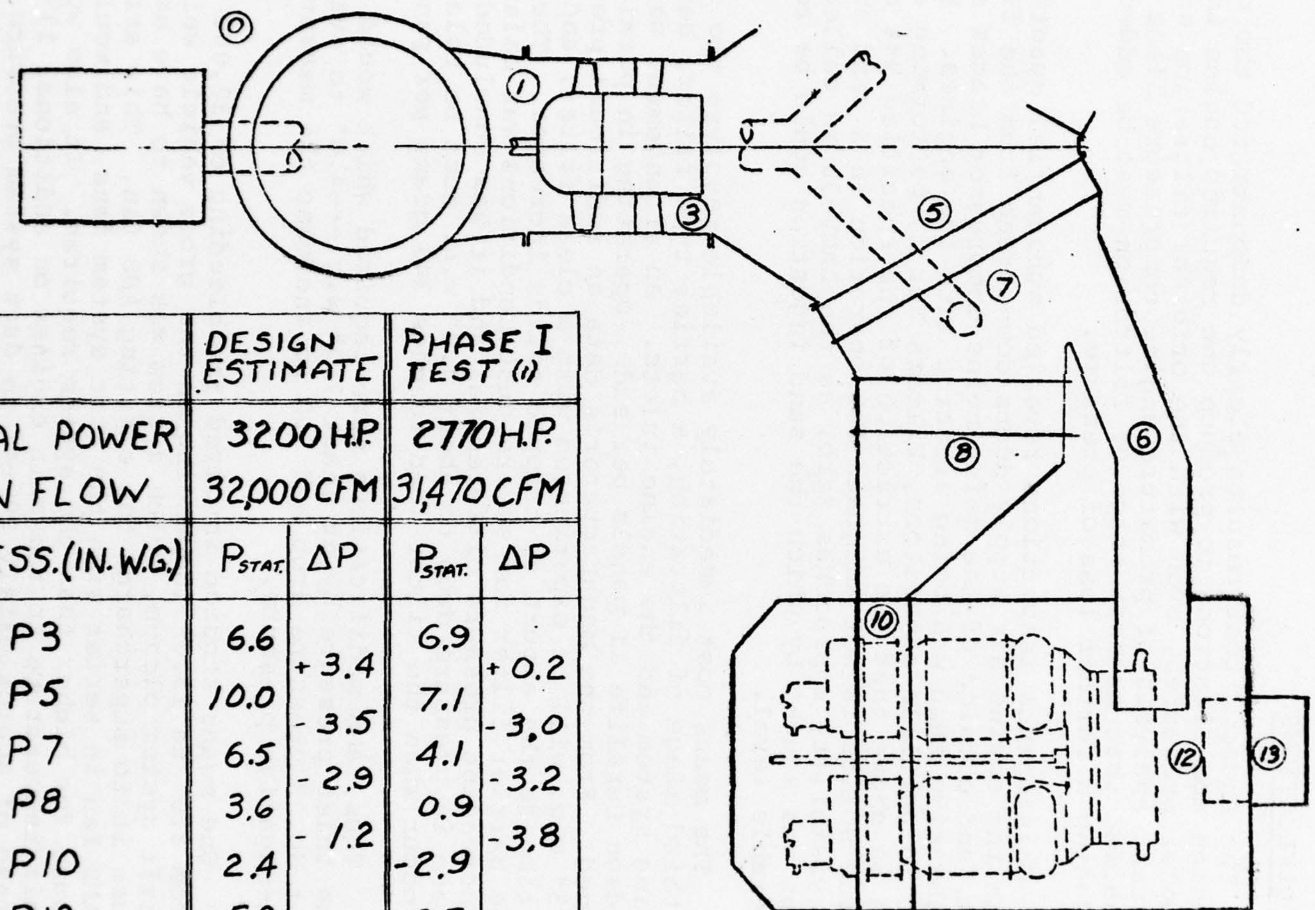
It can be deduced from the fan manufacturer's data that at the designed rate of flow rate of 32,000 CFM the static pressure of the discharge of the fan annulus is approximately 6.1" w.g. with a velocity head of 7.9" w.g. The data in Figure 4 indicates that little if any of this kinetic head is being recovered.

The filtration devices appeared to be performing reasonably close to the predictions, as indicated by the similarity of predicted and measured ΔP's between Stations 5-7 and 7-8.

At the inlet to the engine compartment, the data indicates that pressure losses between Stations 8 and 10 are more than three times the predicted values, due most probably to an insufficient inlet area producing excessive inlet velocity and turbulence in the chamber.

The pressure in the oil cooler bay, Station 12, is about half of the predicted value. Although the pressure drop across the coolers, between Stations 12 and 13 is about what was predicted, it was attained only with full-open louver doors at the exit, while the prediction was

COMPARISON OF DESIGN ESTIMATED PRESSURES WITH PHASE I TEST RESULTS



	DESIGN ESTIMATE		PHASE I TEST (1)	
TOTAL POWER	3200 H.P.		2770 H.P.	
FAN FLOW	32,000 CFM		31,470 CFM	
PRESS. (IN. W.G.)	$P_{STAT.}$	ΔP	$P_{STAT.}$	ΔP
P3	6.6		6.9	
		+ 3.4		+ 0.2
P5	10.0		7.1	
		- 3.5		- 3.0
P7	6.5		4.1	
		- 2.9		- 3.2
P8	3.6		0.9	
		- 1.2		- 3.8
P10	2.4		-2.9	
P12	5.2		2.7	
		- 1.3		- 1.2
P13	3.9		1.5	

(1) TEST NO. 6-(C3b0616), UNDER WAY

FIG 4

based on partially closed louvers. Thus, the oil cooling system had nothing left in hand to meet higher than nominal cooling requirements.

AMS MODIFICATIONS

The Phase I test results clearly demonstrated the need for AMS design modifications to produce the required engine inlet and oil cooler pressures, even with the original filtration scheme. Concurrent analysis of premature engine compressure blade erosion also showed that another stage of filtration must be added, introducing a further loss of pressure.

Maintenance inspections revealed substantial quantities of sand in the engine air supply ducts downstream from the filtration system, and erosion of the main engine compressor blades confirmed that abrasive sand was being airborne into the engines. Even with the solid particle separators, Filters No. 1, performing as intended, it can be shown that the extraction of the specified 94% of the airborne solids is not adequate for operation in a sand environment where visibility approaches zero, as the LACV-30 is called on to do. A means was sought by which the sand ingestion could be reduced to a tolerable level.

The means most immediately available involves the installation of a third stage of filtration, a barrier type filter, between the existing system and the engine inlets. An arrangement using four Donaldson Duralife II panels per side, operating in parallel was designed. From the manufacturer's data an additional pressure loss of 1.5" w.g. will be experienced with a clean filter, and will increase with time as the amount of trapped solids increases. The cycle life of the barrier filter for severe dust conditions was balanced against the increasing pressure differential and it was concluded that an increase in pressure drop to about 4.0" w.g. must be tolerated. This will occur when the filter load reaches 340 grams per panel.

Thus, AMS modifications were required which would raise the engine inlet pressure by at least 7.0" w.g.---4.0" to overcome the filter No. 3 pressure drop and 3.0 to increase the measured -2.4" to a non-negative pressure.

One means studied involved the bleeding of 32,000 CFM of air at from 8.0" to 15.0" (depending on the gross vehicle weight) from the lift system plenum, which system was shown to have ample capacity, and use it to supercharge the existing AMS fan. This arrangement places the AMS fan in series with the lift system fans, and would provide pressure for higher than the system requires. It also would increase the air temperature to the main engines on additional 11^{o}F. The increase of approximately 80 psf in duct system pressure would require some reinforcement of the existing ducts, and a substantial duct addition between the lift fan plenum and the existing AMS fan inlet. These additions were estimated to increase weight by about

600 pounds, at the expense of payload, and to have an adverse (rearward) effect on the location of the center of gravity of the vehicle. These considerations as well as the cost and elapsed time required for designs, fabrications and installations turned attention to other means of increasing AMS pressures. Potential means included:

1. An improved inlet to the AMS fan.

2. Reducing the AMS fan airload by supplying oil cooling air from the lift system.

3. Use of a diffuser at the fan exit.

4. Enlarging the entrance to the engine inlet plenum.

An inlet elbow designed to minimize turning losses and provide a more uniform velocity distribution to the AMS fan face is available from the fan manufacturer, and was considered. A modified inlet at the top of the AMS stack was also considered. This would replace the existing funnel configuration with a rounded bellmouth inlet, in an attempt to minimize losses in static and, especially, forward speed operation. A diversity of opinion existed, however, as to the probable benefit of this rather major change, and that additional data was needed on the potential for improvement in this area. To obtain this data, it was decided to test an ideal, though impractical, inlet to the AMS fan.

From the AMS fan performance characteristics, Figure 5, it can be shown that if the flow rate is reduced from the designed level of 32,000 cfm by the amount of the cooling air load (approximately 7,000 cfm) the fan discharge total pressure will rise approximately 4.0" w.g., an amount which would fully offset the increase in resistance caused by the addition of a third stage of filtration. To replace the cooling air supply it was noted that for the first alternative the lift system had ample capacity to provide 32,000 cfm with no significant effect on the vehicle. It follows that one-fifth that amount can be diverted for cooling without difficulty. For this it is proposed that plenum air will be taken from the side deck adjacent to and immediately outboard from each of the two power plants, Figure 6. This arrangement devotes the AMS fan to the supply of engine combustion air only, and reassigns the cooling load to the lift system fans. This scheme avoids the weight penalties and the higher engine air inlet temperatures with the corresponding penalty in power loss, and will require less time. Another positive effect of the 20% reduction in fan rate of flow will be a reduction of some 40% in system pressure losses upstream of Filter No. 2.

A high priority was accorded the recovery of a greater portion of the fan discharge kinetic head, estimated to approach 6.0" w.g. The test data summarized in Figure 4 indicates that virtually none of this head is recovered (the ΔP between Stations 3 and 5 is only 0.2" w.g.) in the present arrangement. To accomplish this, a diffuser was designed for installation in place of the two splitters,

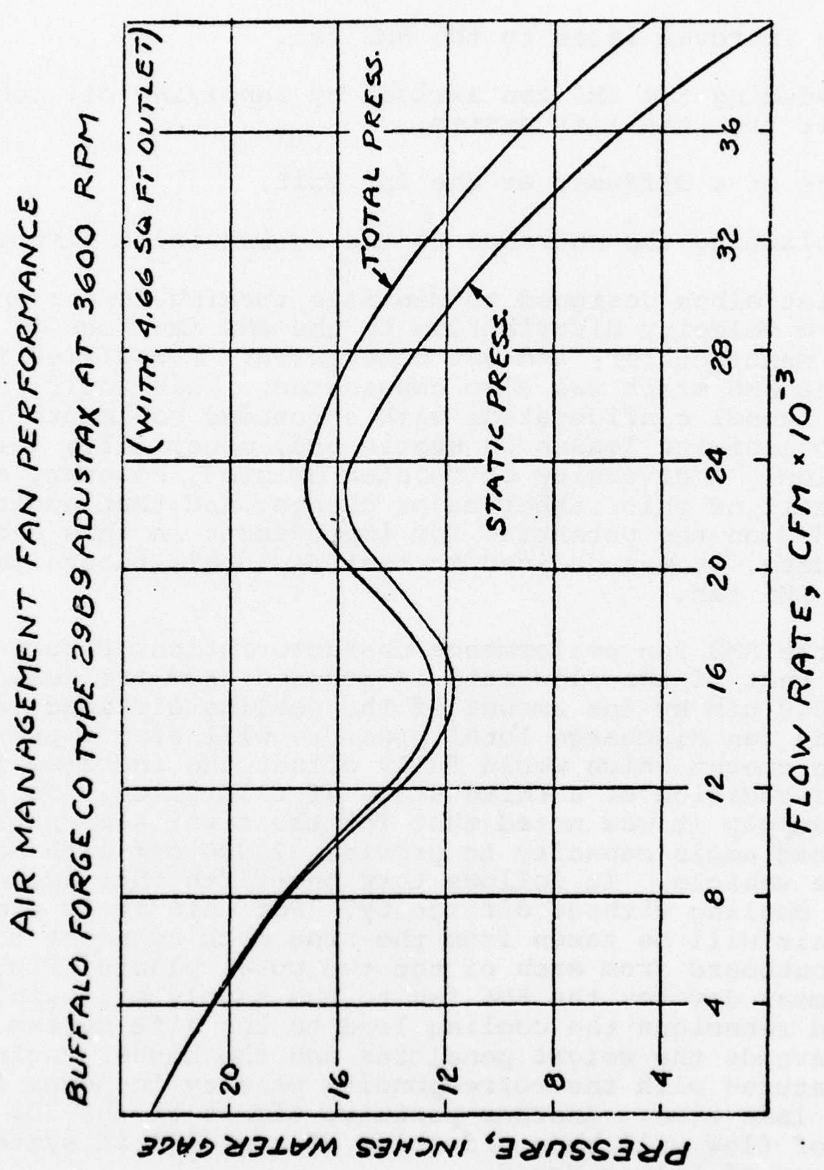

AIR MANAGEMENT FAN PERFORMANCE
BUFFALO FORGE CO TYPE 29B9 ADUSTAX AT 3600 RPM
(WITH 4.66 SQ FT OUTLET)
TOTAL PRESS.
STATIC PRESS.
PRESSURE, INCHES WATER GAGE
20
16
12
8
4
4
8
12
16
20
24
28
32
36
FLOW RATE, CFM × 10^{-3}

FIG. 5

DUCT ARRANGEMENT TO SUPPLY LIFT SYSTEM AIR FOR MAIN ENGINE COOLING PURPOSES.

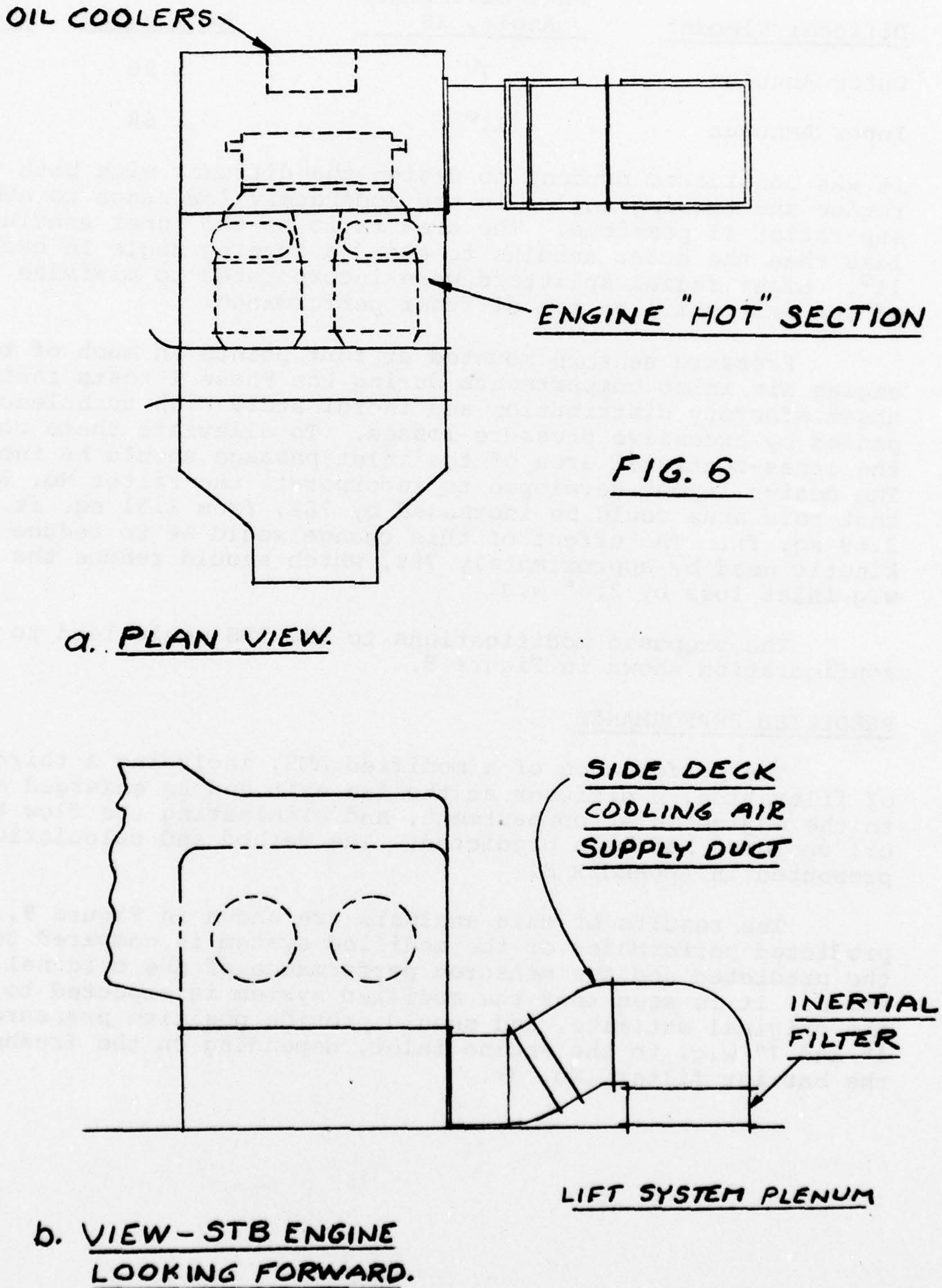


FIG. 6

Figure 1. Because of the relatively short axial distance available, the concept selected consists of two concentric annular diffusers, Figure 7, with principal parameters as follows:

Diffuser Element	Wall Divergence Angle, 2θ	Area Ratio	Est. Recovery
Outer Annulus	7^{o}	1.96	59%
Inner Annulus	11^{o}	1.68	53%

It was considered prudent to design the diffuser with both the area ratios and turning angles in the moderately low range to avoid separation if possible. The area ratio of the inner annulus was made less than the outer annulus to avoid a turning angle in excess of 11^{o}. Eight radial splitters were incorporated to minimize the effect of fan exit whirl on the diffuser performance.

Pressure sensors mounted at four points in each of the two engine air inlet compartments during the Phase I tests indicated unsatisfactory distribution and inordinately high turbulence, accompanied by excessive pressure losses. To alleviate these conditions the cross-sectional area of the inlet passage should be increased. The design layout developed to incorporate the Filter No. 3 showed that this area could be increased by 78%, from 1.51 sq. ft. to 2.69 sq. ft. The effect of this change would be to reduce the kinetic head by approximately 78%, which should reduce the 3.8" w.g inlet loss by 2.6" w.g.

The proposed modifications to the AMS would lead to the configuration shown in Figure 8.

PREDICTED PERFORMANCE

The performance of a modified AMS, including a third stage of filtration, a diffuser at the fan exit and an enlarged entrance to the engine inlet compartment, and eliminating the flow to the oil coolers, has been predicted. The method and calculations are presented in Appendix B.

The results of this analysis are shown in Figure 9, where the predicted performance of the modified system is compared to both the predicted and the measured performance of the original configuration. It is seen that the modified system is expected to exceed the original estimate, and should provide positive pressures between 4" and 7" w.g. to the engine inlet, depending on the freshness of the barrier filter (No. 3).

LACV-30

AIR MANAGEMENT FAN DISCHARGE DIFFUSER

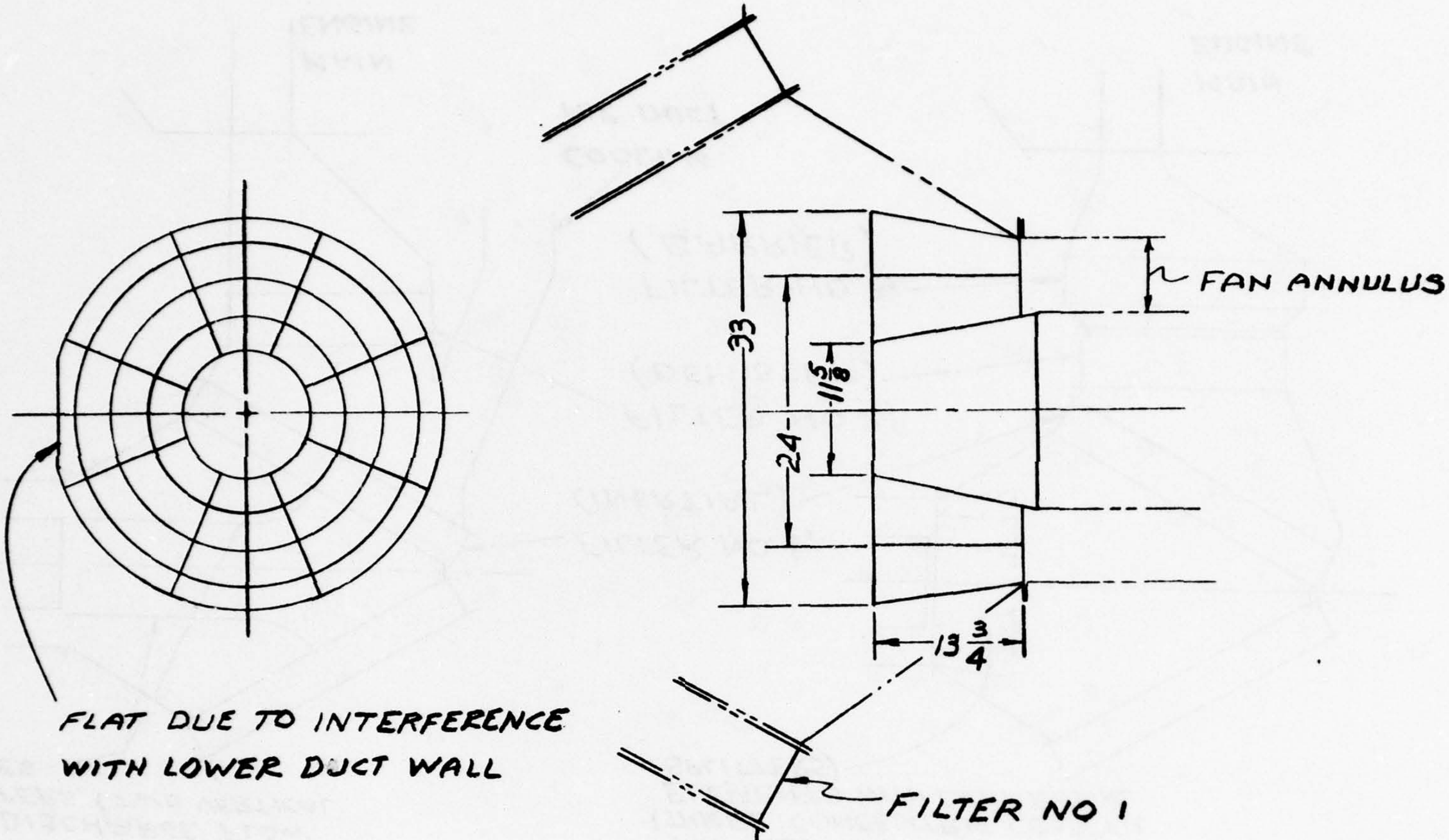
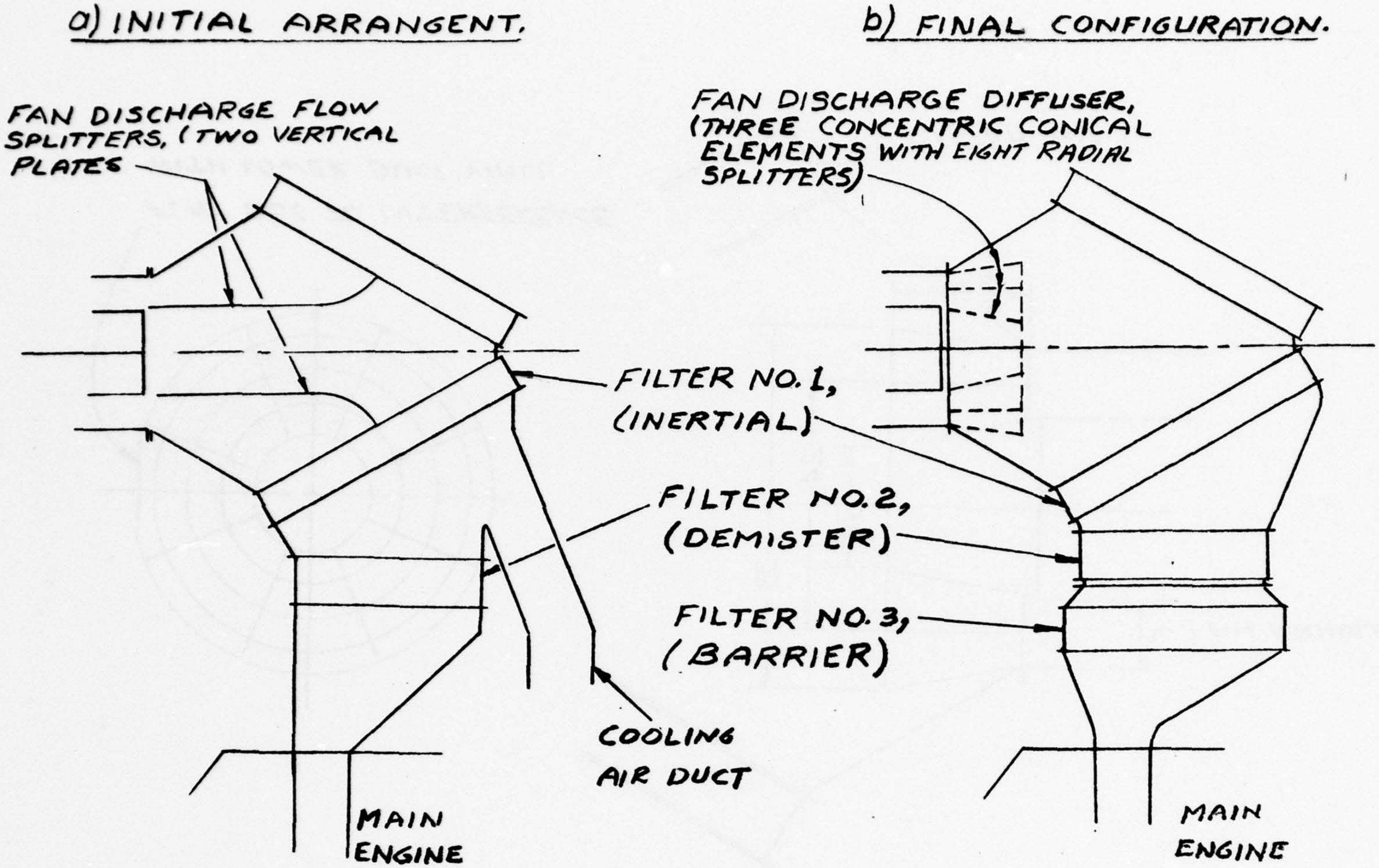
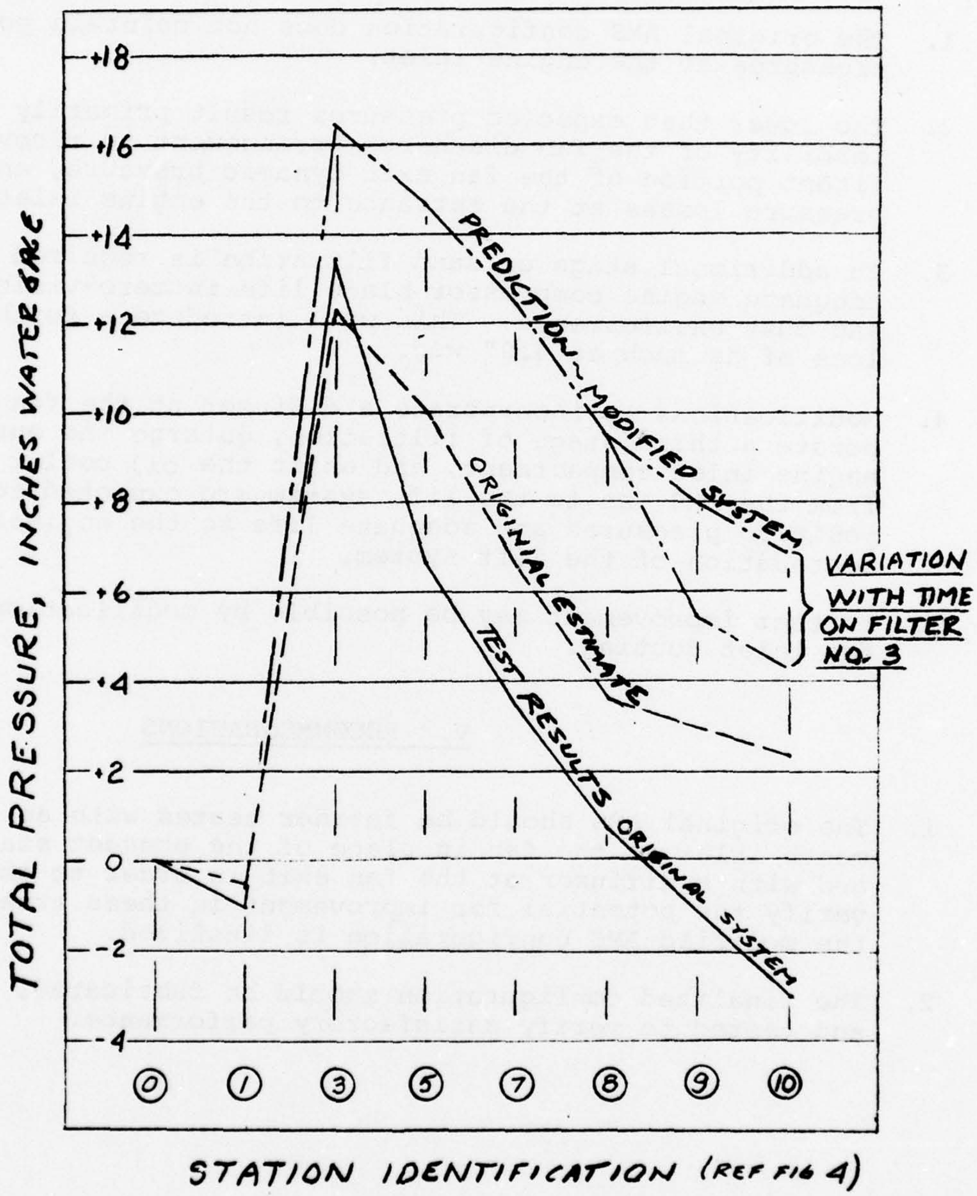


FIG 7



AIR DUCT MODIFICATION TO PROVIDE 3RD STAGE OF FILTRATION OF AIR TO MAIN ENGINES, ELIMINATE THE COOLING AIR DUCT, AND REPLACE SPLITTERS WITH A DIFFUSER.

FIG 8



AMS PRESSURE DISTRIBUTIONS. ESTIMATE & TEST OF ORIGINAL SYSTEM; EST. OF MODIFIED SYSTEM

FIG. 9

IV. CONCLUSIONS

The following conclusions are drawn from the results of the Phase I tests and analysis.

1. The original AMS configuration does not maintain positive pressures at the engine inlet.
2. The lower than expected pressures result primarily from the inability of the fan discharge arrangement to recover any significant portion of the fan exit dynamic pressure, and from high pressure losses at the entrance to the engine inlet compartment.
3. An additional stage of sand filtration is required to provide adequate engine compressor blade life in zero-visibility sand and dust environments. This will introduce a further pressure loss of as much as 4.0" w.g.
4. Modifications to incorporate a diffuser at the fan exit, incorporate a third stage of filtration, enlarge the entrance to the engine inlet compartment, and shift the oil cooler air load from the AMS fan to the lift system are expected to restore positive pressures and adequate life to the engines, without degradation of the lift system.
5. Further improvement may be possible by modifications to the fan inlet ducting.

V. RECOMMENDATIONS

1. The original AMS should be further tested with an ideal bellmouth inlet to the fan in place of the present stack and elbow and with a diffuser at the fan exit in order to ascertain or verify the potential for improvement in these areas, before the modified AMS configuration is finalized.
2. The finalized configuration should be fabricated, installed and tested to verify satisfactory performance.

APPENDIX A

PHASE I TEST DATA

SUMMARY OF AMS TESTS

TEST NO.	TEST DATE (1976)	TEST CONFIGURATION A	B	C	D
1	June 8, 9	1	1	1	1
2	10		1	2	
3	11		2	1	
4	15		3		
5	15		1		
6	16		1		2

VARIABLE		CONFIGURATION
A - Fan Inlet Duct	1	Inlet Stack and Elbow
	2	Inlet Bell
B - Fan Blade Angle	1	$\beta = 36^{\circ}$ (as delivered)
	2	$\beta = 38\frac{1}{2}^{\circ}$
	3	$\beta = 33^{\circ}$
C - Oil Cooler Louvres	1	Full Open
	2	Half Open
D - Vehicle Condition	1	Tethered
	2	Underway

TEST No. 1, C1A0608

```
                              INPUT DATA
N2=    0.0      0.0      0.0      0.0
 TOP      0.0      0.0      0.0      0.0
STACK VEL. HD.=      0.65     0.70     0.65     0.75     0.73     0.75     0.40     0.40     0.35
STACK STATIC HD.=   -0.80    -0.80    -0.80    -0.75    -0.80    -0.75    -0.80    -0.75    -0.80
FAN VEL. HD.=       5.900   2.200   4.900   4.700
FAN STATIC HEAD=       11.000  11.500  11.000  11.500
PRESS. AT DONALDSON-STBD       12.000  11.000  13.000  12.000
PRESS. AT DONALDSON-PORT=       10.500  12.000  11.250  12.500
OIL COOLER VEL. HD.= 3.100     OIL COOLER STATIC= 7.000
PEERLESS PRESS-STBD=11.000     PORT=10.250
PRESS AFT OF PEERLESS-STBD=10.750     PORT=10.250
ENGINE PLENUM PRESS-STBD=   10.50     10.50    10.50     10.50
ENGINE PLENUM PRESS-PORT=   10.00      9.75    10.40     10.00
SCAV.  EXH. PRESS=      5.400  HOT SECT. PRESS.=      5.300  COOLER PRESS=      3.200
OUTSIDE AIR TEMP.=  98.000
STACK TEMPS. =      87.000      84.000      84.000      84.000
FAN DISCHARGE TEMP.=  93.000
ENGINE PLENUM AIR TEMP.=    94.00    95.00


                              ENGINE PREFORMANCE
TEMP=   94.00     ADJ. HP=     0.0         TEMP=    95.00     ADJ. HP=     0.0
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.0
ENGINE AIR(BOTH SIDES)-CFM=  0.0            TAVG(3&4)=  94.500


                              STACK PERFORMANCE
AVG STACK TEMP=       84.75   TEMP RISE IN STACK      -13.25
STACK PRESSURES   VEL= 0.611   STATIC=-0.787  TOTAL HEAD=-0.177
FLOW IN STACK-CFM=  0.2108E 05


                              FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 13.73
FAN DISCHARGE PRESS. STATIC=11.250   VEL. HEAD= 4.425   TOTAL HEAD=15.675
STATIC PRESS. COR.=      11.809  TOTAL PRESS. COR.=      16.233
FAN PRESS INCREASE=15.852  FAN FLOW CFM=  0.2396E 05  FAN HORSEPOWER=  0.5984E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2252E 05


                              APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1608E 04
OIL COOLER FLOW CFM=  0.1298E 05    VEL. FT/SEC=  0.1202E 03


                              SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB= 12.00    PORT= 11.56    AVG= 11.78
DONALDSON PRESS. DROP, STB=  1.00    PORT=  1.31     AVG=  1.16
PEERLESS PRESS. DROP,  STB=  0.25    PORT=  0.0      AVG =  0.13
PRESS DROP TO ENG.,   STB=  0.25    PORT=  0.21     AVG=  0.23
PLENUM PRESS.,  PORT=     10.500  STBD=     10.037  AVG=     10.269
SCAV. PRESS. DROP=       4.850
OIL COOLER DUCT DROP=        3.250
DUCT TO HOT COMP. DROP=        1.700
DUCT TO OIL COOLER DROP=        3.800
```

TEST NO. 1 CIB0608

```
                         INPUT DATA
N2=  40.000  39.500  41.000  41.000
 TOP    3.000   4.000   3.000   4.000
STACK VEL. HD.=      0.80     0.91     0.78     0.95     0.91     1.20     0.67     0.75     0.10
STACK STATIC HD.=    -1.00    -1.10    -1.00    -0.80    -0.20    -0.90    -0.75    -1.00    -1.00
FAN VEL. HD.=       7.000   2.700   6.800   4.500
FAN STATIC HEAD=        10.000  10.500   9.800   9.900
PRESS. AT DONALDSON-STBD        11.000   9.500  12.250   9.500
PRESS. AT DONALDSON-PORT=         9.000  11.000  11.000  11.750
OIL COOLER VEL. HD.= 2.400    OIL COOLER STATIC= 6.000
PEERLESS PRESS-STBD= 9.000    PORT= 8.600
PRESS AFT OF PEERLESS-STBD= 8.300    PORT= 8.000
ENGINE PLENUM PRESS-STBD=   8.00    7.90    7.50    7.40
ENGINE PLENUM PRESS-PORT=   7.20    7.00    7.40    7.00
SCAV.  EXH. PRESS=     4.400  HOT SECT. PRESS.=     4.400  COOLER PRESS=     2.800
OUTSIDE AIR TEMP.=  98.000
STACK TEMPS. =      84.000    87.000    93.000    85.000
FAN DISCHARGE TEMP.=  98.000
ENGINE PLENUM AIR TEMP.=  102.00  132.00

                         ENGINE PREFORMANCE
TEMP=  102.00    ADJ. HP=    0.4696E 02TEMP=  132.00    ADJ. HP=    0.4576E 02
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.4887E 02
ENGINE AIR(BOTH SIDES)-CFM=  0.1235E 05  TAVG(3&4)= 117.000

                         STACK PERFORMANCE
AVG STACK TEMP=      87.25    TEMP RISE IN STACK       -10.75
STACK PRESSURES  VEL= 0.789  STATIC=-0.896  TOTAL HEAD=-0.107
FLOW IN STACK-CFM=  0.2369E 05

                         FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 12.99
FAN DISCHARGE PRESS. STATIC=10.050  VEL. HEAD= 5.250  TOTAL HEAD=15.300
STATIC PRESS. COR.=     10.597  TOTAL PRESS. COR.=     15.847
FAN PRESS INCREASE=15.407  FAN FLOW CFM=  0.2611E 05  FAN HORSEPOWER=  0.6338E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2490E 05

                         APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1616E 04
OIL COOLER FLOW CFM=  0.1147E 05   VEL. FT/SEC=  0.1062E 03

                         SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB= 10.56   PORT= 10.69   AVG= 10.62
DONALDSON PRESS. DROP, STB=  1.56   PORT=  2.09    AVG=  1.83
PEERLESS PRESS. DROP,  STB=  0.70   PORT=  0.60    AVG =  0.65
PRESS DROP TO ENG.,  STB=  0.60   PORT= 0.85   AVG= 0.72
PLENUM PRESS.,  PORT=      7.700  STBD=      7.150  AVG=       7.425
SCAV. PRESS. DROP=      4.200
OIL COOLER DUCT DROP=        2.600
DUCT TO HOT COMP. DROP=        1.600
DUCT TO OIL COOLER DROP=        3.200
```

3

TEST No. 1 C2A0608

```
                                  INPUT DATA
N2=  94.500  94.200  94.200  95.500
 TOP     20.000  21.000  20.000  20.000
STACK VEL. HD.=      1.00      1.24     0.90     1.12     0.90     1.40     0.80     0.40     4.20
STACK STATIC HD.=   -1.20     -1.40    -1.40    -1.20    -1.40    -1.20    -1.10    -0.50    -1.00
FAN VEL. HD.=      6.000    5.200    6.700   10.000
FAN STATIC HEAD=         6.000    6.000    6.000    6.300
PRESS. AT DONALDSON-STBD          7.600    5.800    3.500    5.400
PRESS. AT DONALDSON-PORT=          4.800    7.800    7.200    8.500
OIL COOLER VEL. HD.= 1.400     OIL COOLER STATIC= 3.000
PFERLESS PRESS-STBD= 4.600     PORT= 4.600
PRESS AFT OF PEERLESS-STBD= 2.500      PORT= 2.200
ENGINE PLENUM PRESS-STBD=      0.80     0.0      -0.70    -2.00
ENGINE PLENUM PRESS-PORT=     -1.30     0.0      -0.80    -1.70
SCAV.  EXH. PRESS=       2.000  HOT SECT. PRESS.=       2.500  COOLER PRESS=      3.000
OUTSIDE AIR TEMP.=  90.000
STACK TEMPS. =      122.000    118.000    117.000    105.000
FAN DISCHARGE TEMP.= 110.000
ENGINE PLENUM AIR TEMP.=  120.00  174.00

                                  ENGINE PREFORMANCE
TEMP=  120.00     ADJ. HP=      0.6269E 03TEMP=  174.00     ADJ. HP=     0.5996E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.6628E 03
ENGINE AIR(BOTH SIDES)-CFM=  0.1756E 05  TAVG(3&4)= 147.000

                                  STACK PERFORMANCE
AVG STACK TEMP=      115.50     TEMP RISE IN STACK        25.50
STACK PRESSURES   VEL= 1.247    STATIC=-1.167  TOTAL HEAD= 0.080
FLOW IN STACK-CFM=  0.2985E 05

                                  FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) =  9.98
FAN DISCHARGE PRESS. STATIC= 6.075  VEL. HEAD= 6.975  TOTAL HEAD=13.050
STATIC PRESS. COR.=        6.737  TOTAL PRESS. COR.=      13.712
FAN PRESS INCREASE=12.970  FAN FLOW CFM=  0.3111E 05  FAN HORSEPOWER=  0.6359E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.3048E 05

                                  APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1650E 04
OIL COOLER FLOW CFM=  0.8857E 04    VEL. FT/SEC=  0.8201E 02

                                  SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  5.57    PORT=  7.07    AVG=  6.32
DONALDSON PRESS. DROP, STB=  0.97    PORT=  2.47    AVG=  1.72
PEERLESS PRESS. DROP,   STB=  2.10    PORT=  2.40    AVG =  2.25
PRESS DROP TO ENG.,  STB=  2.97    PORT=  3.15     AVG=  3.06
PLENUM PRESS.,   PORT=      -0.475  STBD=      -0.950  AVG=      -0.712
SCAV. PRESS. DROP=        2.600
OIL COOLER DUCT DROP=        1.600
DUCT TO HOT COMP. DROP=        0.500
DUCT TO OIL COOLER DROP=        0.0
```

TEST No. 1 C2B0608

```
                              INPUT DATA
N2=  92.500  92.500  93.000  94.000
 TOP    34.000  34.000  34.000   34.000
STACK VEL. HD.=      1.15    1.15     0.85     0.80     0.45     1.00     0.90     1.10     1.10
STACK STATIC HD.=      -1.80    -2.00    -1.50    -1.50    -1.50    -1.50    -1.50    -1.50    -1.50
FAN VEL. HD.=      8.100   4.500   6.200   5.400
FAN STATIC HEAD=        1.000    1.500    5.000    5.000
PRESS. AT DONALDSON-STBD        6.500    4.700    8.500    4.300
PRESS. AT DONALDSON-PORT=         3.500    7.000    6.600    8.500
OIL COOLER VEL. HD.= 0.850    OIL COOLER STATIC= 2.500
PEERLESS PRESS-STBD= 3.600    PORT= 3.600
PRESS AFT OF PEERLESS-STBD= 0.900      PORT= 0.800
ENGINE PLENUM PRESS-STBD=    -1.40     -2.10     -2.80     -4.20
ENGINE PLENUM PRESS-PORT=    -3.80     -1.90     -2.80     -3.40
SCAV.  EXH. PRESS=       1.500  HOT SECT. PRESS.=         2.000  COOLER PRESS=       2.000
OUTSIDE AIR TEMP.=  75.000
STACK TEMPS. =      100.000       93.000      93.000      100.000
FAN DISCHARGE TEMP.= 104.000
ENGINE PLENUM AIR TEMP.=  103.00  125.00

                              ENGINE PREFORMANCE
TEMP=  103.00     ADJ. HP=        0.1050E 04TEMP=  125.00     ADJ. HP=      0.1030E 04
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.1094E 04
ENGINE AIR(BOTH SIDES)-CFM=  0.1891E 05  TAVG(3&4)= 114.000

                              STACK PERFORMANCE
AVG STACK TEMP=         96.50     TEMP RISE IN STACK           21.50
STACK PRESSURES   VEL= 0.996   STATIC=-1.642  TOTAL HEAD=-0.646
FLOW IN STACK-CFM=  0.2722E 05

                              FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) =  6.51
FAN DISCHARGE PRESS. STATIC= 3.125  VEL. HEAD= 6.050   TOTAL HEAD= 9.175
STATIC PRESS. COR.=        3.351  TOTAL PRESS. COR.=        9.401
FAN PRESS INCREASE= 9.821  FAN FLOW CFM=  0.2855E 05  FAN HORSEPOWER=  0.4419E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2789E 05

                              APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1678E 04
OIL COOLER FLOW CFM=  0.6865E 04    VEL. FT/SEC=  0.6356E 02

                              SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  6.00   PORT=  6.40    AVG=  6.20
DONALDSON PRESS. DROP, STB=  2.40    PORT= 2.80     AVG=  2.60
PEERLESS PRESS. DROP,   STB=  2.70    PORT= 2.80     AVG =  2.75
PRESS DROP TO ENG.,   STB=  3.52   PORT=  3.77    AVG=  3.65
PLENUM PRESS.,  PORT=     -2.625  STBD=      -2.975  AVG=     -2.800
SCAV. PRESS. DROP=      2.100
OIL COOLER DUCT DROP=        1.100
DUCT TO HOT COMP. DROP=        0.500
DUCT TO OIL COOLER DROP=       0.500
```

5

TEST No. 1 C2C0608

```
                                   INPUT DATA
N2=  91.750  92.000  91.000  92.000
 TOP    42.000  42.000  44.000  43.000
STACK VEL. HD.=    1.20     1.35     1.00     0.90     0.80     1.25     1.20     1.20     0.90
STACK STATIC HD.=   -2.00    -1.80    -1.60    -1.70    -1.50    -1.60    -1.50    -1.60    -1.50
FAN VEL. HD.=     10.000    9.100    6.800    4.000
FAN STATIC HEAD=        3.000    1.700    4.500    5.000
PRESS. AT DONALDSON-STBD         6.400    4.700    8.000    4.200
PRESS. AT DONALDSON-PORT=          3.500    6.400    6.200    8.000
OIL COOLER VEL. HD.= 0.800     OIL COOLER STATIC= 2.000
PEERLESS PRESS-STBD= 3.000     PORT= 3.000
PRESS AFT OF PEERLESS-STBD= 0.0        PORT= 0.500
ENGINE PLENUM PRESS-STBD=   -0.50    -2.00    -3.50    -4.50
ENGINE PLENUM PRESS-PORT=   -4.00    -2.00    -2.00    -4.50
SCAV.  EXH. PRESS=       1.500  HOT SECT. PRESS.=      1.500  COOLER PRESS=      1.600
OUTSIDE AIR TEMP.=  78.000
STACK TEMPS. =         87.000     85.000     84.000     83.000
FAN DISCHARGE TEMP.=  91.000
ENGINE PLENUM AIR TEMP.=    95.00  112.00


                                   ENGINE PREFORMANCE
TEMP=   95.00     ADJ. HP=      0.1311E 04TEMP=  112.00      ADJ. HP=      0.1292E 04
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.1356E 04
ENGINE AIR(BOTH SIDES)-CFM=  0.1978E 05  TAVG(3&4)= 103.500


                                   STACK PERFORMANCE
AVG STACK TEMP=       84.75      TEMP RISE IN STACK          6.75
STACK PRESSURES  VEL= 1.117   STATIC=-1.733   TOTAL HEAD=-0.617
FLOW IN STACK-CFM=  0.2862E 05


                                   FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) =  7.74
FAN DISCHARGE PRESS. STATIC= 3.550   VEL. HEAD= 7.475   TOTAL HEAD=11.025
STATIC PRESS. COR.=       3.726   TOTAL PRESS. COR.=      11.201
FAN PRESS INCREASE=11.642   FAN FLOW CFM=   0.3116E 05   FAN HORSEPOWER=  0.5715E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2989E 05


                                   APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1608E 04
OIL COOLER FLOW CFM=  0.6582E 04    VEL. FT/SEC=  0.6095E 02


                                   SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  5.82   PORT=  6.02   AVG=  5.92
DONALDSON PRESS. DROP, STB=  2.82    PORT=  3.02    AVG=  2.92
PEERLESS PRESS. DROP,  STB=  3.00    PORT=  2.50    AVG =  2.75
PRESS DROP TO ENG.,   STB=  2.62    PORT=  3.62    AVG=  3.13
PLENUM PRESS..   PORT=     -2.625   STBD=     -3.125   AVG=     -2.875
SCAV. PRESS. DROP=      1.500
OIL COOLER DUCT DROP=      1.000
DUCT TO HOT COMP. DROP=       0.500
DUCT TO OIL COOLER DROP=      0.400
```

TEST No. 2 C1A0610

```
                        INPUT DATA
N2=  42.750  42.500  42.500  43.000
 TOP     2.000   4.000   3.000   3.000
STACK VEL. HD.=     0.60     0.50     0.30     0.60     0.50     0.48     0.60     0.60     0.58
STACK STATIC HD.=   -0.80    -0.80    -0.80    -0.60    -0.70    -0.60    -0.50    -0.80    -0.50
FAN VEL. HD.=       3.200    3.200    3.700    2.600
FAN STATIC HEAD=       10.000  10.500  10.500  11.000
PRESS. AT DONALDSON-STBD        12.000  11.000  12.200  10.000
PRESS. AT DONALDSON-PORT=        10.000  11.300  10.800  11.500
OIL COOLER VEL. HD.= 2.900    OIL COOLER STATIC= 5.000
PEERLESS PRESS-STBD=10.000    PORT= 9.800
PRESS AFT OF PEERLESS-STBD=10.000    PORT= 9.800
ENGINE PLENUM PRESS-STBD=   10.00    10.00    10.00    10.10
ENGINE PLENUM PRESS-PORT=    9.80     9.50     9.00     9.50
SCAV.  EXH. PRESS=       5.200  HOT SECT. PRESS.=     5.000  COOLER PRESS=      4.400
OUTSIDE AIR TEMP.=  87.800
STACK TEMPS. =       89.000      89.000     90.000     91.000
FAN DISCHARGE TEMP.= 100.000
ENGINE PLENUM AIR TEMP.=    99.00  100.00

                        ENGINE PREFORMANCE
TEMP=    99.00     ADJ. HP=     0.4267E 02TEMP=  100.00     ADJ. HP=     0.4263E 02
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.4429E 02
ENGINE AIR(BOTH SIDES)-CFM=  0.1211E 05  TAVG(3&4)=  99.500

                        STACK PERFORMANCE
AVG STACK TEMP=       89.75    TEMP RISE IN STACK        1.95
STACK PRESSURES   VEL= 0.547   STATIC=-0.708  TOTAL HEAD=-0.162
FLOW IN STACK-CFM=  0.2010E 05

                        FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 12.28
FAN DISCHARGE PRESS. STATIC=10.500  VEL. HEAD= 3.175  TOTAL HEAD=13.675
STATIC PRESS. COR.=     11.122  TOTAL PRESS. COR.=     14.297
FAN PRESS INCREASE=13.837  FAN FLOW CFM=  0.2064E 05  FAN HORSEPOWER=  0.4500E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2037E 05

                        APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1664E 04
OIL COOLER FLOW CFM=  0.1263E 05   VEL. FT/SEC=  0.1170E 03

                        SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB= 11.30   PORT= 10.90   AVG= 11.10
DONALDSON PRESS. DROP, STB=  1.30    PORT=  1.10    AVG=  1.20
PEERLESS PRESS. DROP,  STB=  0.0     PORT=  0.0     AVG =  0.0
PRESS DROP TO ENG., STB= -0.02    PORT=  0.35    AVG=  0.16
PLENUM PRESS.,  PORT=    10.025  STBD=      9.450   AVG=       9.737
SCAV. PRESS. DROP=      4.600
OIL COOLER DUCT DROP=       4.800
DUCT TO HOT COMP. DROP=       0.0
DUCT TO OIL COOLER DROP=      0.600
```

7

TEST No. 2 C1B0610

```
                                INPUT DATA
N2=  42.750  42.500  42.500  43.000
 TOP     2.000   4.000    3.000    3.000
STACK VEL. HD.=       0.80     0.60     0.50     0.82     0.78     0.72     0.78     0.82     0.79
STACK STATIC HD.=    -0.90    -1.10    -1.00    -0.80    -1.00    -0.90    -0.70    -1.00    -0.90
FAN VEL. HD.=     3.100   4.580    6.100   3.100
FAN STATIC HEAD=        9.000    9.000  10.000  10.000
PRESS. AT DONALDSON-STBD       11.000    9.200  12.000    9.000
PRESS. AT DONALDSON-PORT=       9.500  11.000  10.000  11.500
OIL COOLER VEL. HD.= 2.500     OIL COOLER STATIC= 4.000
PEERLESS PRESS-STBD= 8.700     PORT= 9.000
PRESS AFT OF PEERLESS-STBD= 8.000     PORT= 7.800
ENGINE PLENUM PRESS-STBD=     8.00     7.80     7.50     7.40
ENGINE PLENUM PRESS-PORT=     7.00     7.40     7.40     7.10
SCAV.  EXH. PRESS=       4.600  HOT SECT. PRESS.=      4.500  COOLER PRESS=      4.200
OUTSIDE AIR TEMP.=  87.800
STACK TEMPS. =       88.000     91.000     91.000     91.000
FAN DISCHARGE TEMP.=  99.000
ENGINE PLENUM AIR TEMP.=   99.00  128.00

                                ENGINE PREFORMANCE
TEMP=    99.00     ADJ. HP=     0.4267E 02TEMP=  128.00      ADJ. HP=     0.4161E 02
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.4429E 02
ENGINE AIR(BOTH SIDES)-CFM=  0.1226E 05  TAVG(3&4)= 113.500

                                STACK PERFORMANCE
AVG STACK TEMP=       90.25     TEMP RISE IN STACK         2.45
STACK PRESSURES   VEL= 0.751   STATIC=-0.917  TOTAL HEAD=-0.166
FLOW IN STACK-CFM=  0.2360E 05

                                FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 11.86
FAN DISCHARGE PRESS. STATIC= 9.500  VEL. HEAD= 4.220  TOTAL HEAD=13.720
STATIC PRESS. COR.=     10.072  TOTAL PRESS. COR.=     14.292
FAN PRESS INCREASE=13.886  FAN FLOW CFM=  0.2360E 05  FAN HORSEPOWER=  0.5165E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2360E 05

                                APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1644E 04
OIL COOLER FLOW CFM=  0.1172E 05   VEL. FT/SEC=  0.1085E 03

                                SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB= 10.30   PORT= 10.50   AVG= 10.40
DONALDSON PRESS. DROP, STB=  1.60    PORT=  1.50     AVG=  1.55
PEERLESS PRESS. DROP,  STB=  0.70    PORT=  1.20     AVG =  0.95
PRESS DROP TO ENG.,  STB=  0.33   PORT=  0.58    AVG=  0.45
PLENUM PRESS.,   PORT=      7.675   STBD=     7.225   AVG=      7.450
SCAV. PRESS. DROP=     4.400
OIL COOLER DUCT DROP=      5.000
DUCT TO HOT COMP. DROP=       -0.500
DUCT TO OIL COOLER DROP=      -0.200
```

TEST No. 2 C2A0610

```
                                  INPUT DATA
N2=  95.300  95.000  94.500  95.500
  TOP   19.000  20.000  19.000  19.000
STACK VEL. HD.=     1.20     1.00     0.80     1.00     1.00     1.00     0.90     0.90     0.95
STACK STATIC HD.=  -1.10    -1.30    -1.20    -1.00    -1.10    -1.00    -0.80    -1.00    -1.00
FAN VEL. HD.=      3.200   5.100   6.150   4.100
FAN STATIC HEAD=      5.800   6.000   7.000   7.000
PRESS. AT DONALDSON-STBD      8.200   6.200   8.300   6.000
PRESS. AT DONALDSON-PORT=       5.600   8.000   7.200   9.000
OIL COOLER VEL. HD.= 1.150    OIL COOLER STATIC= 3.000
PEERLESS PRESS-STBD= 5.000    PORT= 4.800
PRESS AFT OF PEERLESS-STBD= 3.000    PORT= 2.700
ENGINE PLENUM PRESS-STBD=     1.40    0.50   -0.40   -1.00
ENGINE PLENUM PRESS-PORT=    -0.80    0.60   -0.20   -1.00
SCAV.  EXH. PRESS=       2.300  HOT SECT. PRESS.=      2.800  COOLER PRESS=      2.700
OUTSIDE AIR TEMP.=  95.000
STACK TEMPS. =   87.000     88.000     88.000     89.000
FAN DISCHARGE TEMP.=  95.000
ENGINE PLENUM AIR TEMP.=    95.00  140.00

                                  ENGINE PREFORMANCE
TEMP=    95.00     ADJ. HP=      0.6123E 03TEMP=  140.00     ADJ. HP=     0.5889E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--   0.6332E 03
ENGINE AIR(BOTH SIDES)-CFM=  0.1707E 05  TAVG(3&4)= 117.500


                                  STACK PERFORMANCE
AVG STACK TEMP=       88.00     TEMP RISE IN STACK        -7.00
STACK PRESSURES   VEL= 1.029    STATIC=-1.067   TOTAL HEAD=-0.037
FLOW IN STACK-CFM=  0.2758E 05


                                  FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) =   9.05
FAN DISCHARGE PRESS. STATIC= 6.450  VEL. HEAD= 4.637  TOTAL HEAD=11.087
STATIC PRESS. COR.=      6.811  TOTAL PRESS. COR.=      11.448
FAN PRESS INCREASE=11.125  FAN FLOW CFM=  0.2477E 05  FAN HORSEPOWER=  0.4343E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2618E 05


                                  APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1654E 04
OIL COOLER FLOW CFM=  0.7921E 04    VEL. FT/SEC=  0.7334E 02


                                  SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  7.17   PORT=  7.45   AVG=  7.31
DONALDSON PRESS. DROP, STB=  2.17   PORT=  2.65    AVG=  2.41
PEERLESS PRESS. DROP,  STB=  2.00   PORT=  2.10    AVG =  2.05
PRESS DROP TO ENG.,   STB=  2.87   PORT=  3.05   AVG=  2.96
PLENUM PRESS.,  PORT=     0.125  STBD=    -0.350   AVG=     -0.113
SCAV. PRESS. DROP=      2.500
OIL COOLER DUCT DROP=     1.800
DUCT TO HOT COMP. DROP=       0.200
DUCT TO OIL COOLER DROP=      0.300
```

9

TEST NO. 3 CIA0611

```
                            INPUT DATA
N2=  0.0    0.0    0.0    0.0
 TOP    0.0    0.0    0.0    0.0
STACK VEL. HD.=    0.55     0.60     0.40     0.05     0.25     0.24     0.45     0.55     0.58
STACK STATIC HD.=    -0.80    -0.80    -0.70    -0.70    -0.80    -0.60    -0.50    -0.50    -0.50
FAN VEL. HD.=    5.000   2.800   3.600   3.400
FAN STATIC HEAD=        9.500  10.000  10.000  10.300
PRESS. AT DONALDSON-STBD       11.200  10.200  11.000  10.000
PRESS. AT DONALDSON-PORT=        9.500  10.700  10.200  11.200
OIL COOLER VEL. HD.= 2.700     OIL COOLER STATIC= 6.000
PEERLESS PRESS-STBD= 9.900     PORT= 9.500
PRESS AFT OF PEERLESS-STBD= 9.500     PORT= 9.200
ENGINE PLENUM PRESS-STBD=      9.50     9.50     9.50     9.40
ENGINE PLENUM PRESS-PORT=      9.20     8.60     9.00     9.10
SCAV.  EXH. PRESS=      4.800  HOT SECT. PRESS.=      4.800  COOLER PRESS=      0.0
OUTSIDE AIR TEMP.=  92.000
STACK TEMPS. =       85.000      85.000      86.000      87.000
FAN DISCHARGE TEMP.=  95.000
ENGINE PLENUM AIR TEMP.=  92.00    93.00

                            ENGINE PREFORMANCE
TEMP=    92.00    ADJ. HP=     0.0        TEMP=    93.00     ADJ. HP=     0.0
 AVERAVGE HORSEPOWER--BOTH ENGINES--  0.0
ENGINE AIR(BOTH SIDES)-CFM=  0.0          TAVG(3&4)=  92.500

                            STACK PERFORMANCE
AVG STACK TEMP=       85.75    TEMP RISE IN STACK        -6.25
STACK PRESSURES  VEL= 0.443    STATIC=-0.692   TOTAL HEAD=-0.248
FLOW IN STACK-CFM=  0.1758E 05

                            FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 12.02
 FAN DISCHARGE PRESS. STATIC= 9.950  VEL. HEAD= 3.700  TOTAL HEAD=13.650
STATIC PRESS. COR.=     10.463  TOTAL PRESS. COR.=     14.163
FAN PRESS INCREASE=13.898  FAN FLOW CFM=  0.2212E 05  FAN HORSEPOWER=  0.4844E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.1985E 05

                            APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1640E 04
OIL COOLER FLOW CFM=  0.1214E 05   VEL. FT/SEC=  0.1124E 03

                            SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB= 10.60    PORT= 10.40    AVG= 10.50
DONALDSON PRESS. DROP, STB=  0.70    PORT=  0.90    AVG=  0.80
PEERLESS PRESS. DROP,  STB=  0.40    PORT=  0.30    AVG =  0.35
PRESS DROP TO ENG.,  STB=  0.03    PORT=  0.23    AVG=  0.13
PLENUM PRESS.,   PORT=      9.475  STBD=      8.975  AVG=      9.225
SCAV. PRESS. DROP=     4.700
OIL COOLER DUCT DROP=      3.500
DUCT TO HOT COMP. DROP=      1.200
DUCT TO OIL COOLER DROP=      6.000
```

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TEST No. 3 C1B0611

```
                                          INPUT DATA
N2=  42.000  41.500  42.000  42.500
  TOP     2.000   4.000   3.000   4.000
STACK VEL. HD.=     0.80     0.90     0.65     0.30     0.15     0.10     0.60     0.70     0.80
STACK STATIC HD.=  -1.00    -1.20    -1.00    -1.00    -1.10    -0.90    -0.80    -0.90    -0.90
FAN VEL. HD.=        7.400   3.800   5.800   4.400
FAN STATIC HEAD=        10.000   10.500  10.500  10.500
PRESS. AT DONALDSON-STBD          11.500   9.500  12.500   9.500
PRESS. AT DONALDSON-PORT*           9.500  11.000  10.500  12.000
OIL COOLER VEL. HD.= 3.600     OIL COOLER STATIC= 6.000
PEERLESS PRESS-STBD= 9.000     PORT= 9.000
PRESS AFT OF PEERLESS-STBD= 8.500     PORT= 8.300
ENGINE PLENUM PRESS-STBD=     8.50     8.00     7.70     7.50
ENGINE PLENUM PRESS-PORT=     7.40     7.20     7.20     7.20
SCAV.  EXH. PRESS=        4.600  HOT SECT. PRESS.=      4.600  COOLER PRESS=      0.0
OUTSIDE AIR TEMP.=  92.000
STACK TEMPS. =      110.000      90.000     85.000     84.000
FAN DISCHARGE TEMP.=  93.000
ENGINE PLENUM AIR TEMP.=    94.00  123.00

                                          ENGINE PREFORMANCE
TEMP=    94.00    ADJ. HP=      0.4571E 02TEMP=  123.00     ADJ. HP=     0.4456E 02
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.4723E 02
ENGINE AIR(BOTH SIDES)-CFM=  0.1224E 05  TAVG(3&4)= 108.500

                                          STACK PERFORMANCE
AVG STACK TEMP=        92.25      TEMP RISE IN STACK          0.25
STACK PRESSURES  VEL= 0.617   STATIC=-0.983  TOTAL HEAD=-0.367
FLOW IN STACK-CFM=  0.2072E 05

                                          FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 13.37
FAN DISCHARGE PRESS. STATIC=10.375  VEL. HEAD= 5.350  TOTAL HEAD=15.725
STATIC PRESS. COR.=     11.040  TOTAL PRESS. COR.=      16.390
FAN PRESS INCREASE=16.092  FAN FLOW CFM=  0.2668E 05  FAN HORSEPOWER=  0.6766E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2370E 05

                                          APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1594E 04
OIL COOLER FLOW CFM=  0.1399E 05    VEL. FT/SEC=  0.1295E 03

                                          SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB= 10.75   PORT= 10.75   AVG= 10.75
DONALDSON PRESS. DROP, STB=  1.75   PORT=  1.75    AVG=  1.75
PEERLESS PRESS. DROP,   STB=  0.50   PORT=  0.70    AVG =  0.60
PRESS DROP TO ENG.,  STB*  0.58   PORT=  1.05    AVG=  0.81
PLENUM PRESS.,   PORT=     7.925  STBD=      7.250  AVG=      7.587
SCAV. PRESS. DROP=     4.400
OIL COOLER DUCT DROP=       3.000
DUCT TO HOT COMP. DROP=       1.400
DUCT TO OIL COOLER DROP=       6.000
```

TEST No. 3 C2A0611

```
                              INPUT DATA
N2=  94.500  94.500  94.500  95.500
 TOP    18.000  20.000  19.000  19.000
STACK VEL. HD.=     1.00     1.10     0.90     0.80     0.60     0.70     0.80     0.90     0.90
STACK STATIC HD.=    -1.10    -1.30    -1.10    -1.10    -1.10    -1.00    -0.90    -1.00    -1.00
FAN VEL. HD.=      7.400   4.900   6.100   5.400
FAN STATIC HEAD=       7.700   7.300   7.400   7.000
PRESS. AT DONALDSON-STBD        8.500   6.300  10.000    6.000
PRESS. AT DONALDSON-PORT=        5.700   8.000   7.900    9.500
OIL COOLER VEL. HD.= 1.300     OIL COOLER STATIC= 3.600
PEERLESS PRESS-STBD= 5.500     PORT= 5.400
PRESS AFT OF PEERLESS-STBD= 3.400      PORT= 3.000
ENGINE PLENUM PRESS-STBD=      1.60     0.80     0.0     -1.00
ENGINE PLENUM PRESS-PORT=     -0.60     1.00     0.20    -0.80
SCAV.  EXH. PRESS=       2.600  HOT SECT. PRESS.=       3.000  COOLER PRESS=       0.0
OUTSIDE AIR TEMP.=  92.000
STACK TEMPS. =       87.000       87.000       86.000      95.000
FAN DISCHARGE TEMP.=  92.000
ENGINE PLENUM AIR TEMP.=    93.00  132.00

                              ENGINE PREFORMANCE
TEMP=    93.00     ADJ. HP=      0.6034E 03TEMP=  132.00     ADJ. HP=      0.5832E 03
 AVERAVGE HORSEPOWER--BOTH ENGINES--  0.6229E 03
 ENGINE AIR(BOTH SIDES)-CFM=  0.1695E 05  TAVG(3&4)= 112.500

                              STACK PERFORMANCE
AVG STACK TEMP=        88.75     TEMP RISE IN STACK          -3.25
STACK PRESSURES   VEL= 0.892   STATIC=-1.075  TOTAL HEAD=-0.183
FLOW IN STACK-CFM=  0.2566E 05

                              FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 10.68
FAN DISCHARGE PRESS. STATIC= 7.350   VEL. HEAD= 5.950  TOTAL HEAD=13.300
STATIC PRESS. COR.=       7.772  TOTAL PRESS. COR.=       13.722
FAN PRESS INCREASE=13.483  FAN FLOW CFM=  0.2820E 05  FAN HORSEPOWER=  0.5991E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2693E 05

                              APU AND OIL COOLER FLOWS
 APU AIR FLOW, CFM =  0.1605E 04
OIL COOLER FLOW CFM=  0.8399E 04   VEL. FT/SEC=  0.7776E 02

                              SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  7.70   PORT=  7.77   AVG=  7.74
DONALDSON PRESS. DROP, STB=  2.20    PORT= 2.37     AVG=  2.29
PEERLESS PRESS. DROP,   STB=  2.10    PORT= 2.40     AVG =  2.25
PRESS DROP TO ENG.,   STB=  3.05   PORT= 3.05     AVG=  3.05
PLENUM PRESS.,   PORT=      0.350  STBD=      -0.050  AVG=        0.150
SCAV. PRESS. DROP=    2.800
OIL COOLER DUCT DROP=      1.800
DUCT TO HOT COMP. DROP=        0.600
DUCT TO OIL COOLER DROP=       3.600
```

12

TEST NO. 3 C2B0611

```
                                     INPUT DATA
N2=  89.000  88.500  91.500  92.500
 TOP    30.000  31.000  38.000  38.000
STACK VEL. HD.=      1.20     1.10     1.00     1.10     1.00     1.50     1.40     1.40     1.00
STACK STATIC HD.=   -2.00    -2.00    -2.00    -1.60    -1.60    -1.50    -1.50    -2.00    -1.50
FAN VEL. HD.=      7.000    7.000    6.200    5.200
FAN STATIC HEAD=         5.000    4.300    5.500    5.200
PRESS. AT DONALDSON-STBD        7.000    4.600    7.500    4.600
PRESS. AT DONALDSON-PORT=         4.000    6.500    6.000    8.000
OIL COOLER VEL. HD.= 1.700    OIL COOLER STATIC= 2.000
PEERLESS PRESS-STBD= 3.500    PORT= 3.500
PRESS AFT OF PEERLESS-STBD= 0.600     PORT= 1.500
ENGINE PLENUM PRESS-STBD=   -2.00    -3.50    -3.50    -4.00
ENGINE PLENUM PRESS-PORT=   -3.00    -2.00    -2.50    -3.50
SCAV.  EXH. PRESS=       1.400  HOT SECT. PRESS.=      1.500  COOLER PRESS=      0.0
OUTSIDE AIR TEMP.=  92.000
STACK TEMPS. =        120.000    110.000    110.000    125.000
FAN DISCHARGE TEMP.= 116.000
ENGINE PLENUM AIR TEMP.=  118.00  137.00

                                     ENGINE PREFORMANCE
TEMP=  118.00      ADJ. HP=      0.1017E 04TEMP=  137.00      ADJ. HP=      0.1000E 04
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.1073E 04
ENGINE AIR(BOTH SIDES)-CFM=  0.1900E 05  TAVG(3&4)= 127.500


                                     STACK PERFORMANCE
AVG STACK TEMP=      116.25      TEMP RISE IN STACK        24.25
STACK PRESSURES   VEL= 1.192   STATIC=-1.808   TOTAL HEAD=-0.617
FLOW IN STACK-CFM=  0.3043E 05


                                     FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) =  8.56
FAN DISCHARGE PRESS. STATIC= 5.000   VEL. HEAD= 6.350   TOTAL HEAD=11.350
STATIC PRESS. COR.=       5.552  TOTAL PRESS. COR.=       11.902
FAN PRESS INCREASE=11.967   FAN FLOW CFM=  0.2989E 05   FAN HORSEPOWER=   0.5636E 02
AVG. OF STACK AND FAN FLOW-CFM=   0.3016E 05


                                     APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =   0.1683E 04
OIL COOLER FLOW CFM=   0.9811E 04     VEL. FT/SEC=   0.9084E 02


                                     SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=   5.92    PORT=   6.12     AVG=   6.02
DONALDSON PRESS. DROP, STB=   2.42     PORT=   2.62        AVG=   2.52
PEERLESS PRESS. DROP,   STB=   2.90     PORT=   2.00        AVG =   2.45
PRESS DROP TO ENG.,   STB=   3.85     PORT=   4.25      AVG=   4.05
PLENUM PRESS.,   PORT=      -3.250   STBD=      -2.750   AVG=      -3.000
SCAV. PRESS. DROP=        2.100
OIL COOLER DUCT DROP=          1.500
DUCT TO HOT COMP. DROP=        0.500
DUCT TO OIL COOLER DROP=        2.000
```

13

TEST No. 4 C1B0615

```
                              INPUT DATA
N2=  40.000  40.000  39.000  39.500
  TOP     4.000   4.000   4.000   4.000
STACK VEL. HD.=      0.80     0.90     0.70     0.60     0.40     0.80     0.70     0.80     0.90
STACK STATIC HD.=    -1.00    -1.10    -1.00    -1.00    -1.10    -1.00    -0.90    -1.00    -0.90
FAN VEL. HD.=   .   7.100   2.200   6.300   4.300
FAN STATIC HEAD=        9.500  10.000   9.500   9.500
PRESS. AT DONALDSON-STBD        10.500   8.900  10.700   8.900
PRESS. AT DONALDSON-PORT=         9.000  10.200   9.500  11.500
OIL COOLER VEL. HD.= 2.500     OIL COOLER STATIC= 5.500
PEERLESS PRESS-STBD= 8.900     PORT= 8.500
PRESS AFT OF PEERLESS-STBD= 8.000      PORT= 8.000
ENGINE PLENUM PRESS-STBD=     8.00     7.70     7.40     7.50
ENGINE PLENUM PRESS-PORT=     7.20     7.40     7.30     7.00
SCAV.  EXH. PRESS=       4.600  HOT SECT. PRESS.=     5.500  COOLER PRESS=      0.200
OUTSIDE AIR TEMP.=  72.500
STACK TEMPS. =      110.000    110.000     93.000     95.000
FAN DISCHARGE TEMP.= 104.000
ENGINE PLENUM AIR TEMP.=  105.00  134.00

                              ENGINE PREFORMANCE
TEMP=  105.00     ADJ. HP=    0.5256E 02TEMP=  134.00     ADJ. HP=     0.5126E 02
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.5484E 02
ENGINE AIR(BOTH SIDES)-CFM=  0.1245E 05  TAVG(3&4)= 119.500

                              STACK PERFORMANCE
AVG STACK TEMP=      102.00    TEMP RISE IN STACK        29.50
STACK PRESSURES  VEL= 0.750   STATIC=-1.000  TOTAL HEAD=-0.250
FLOW IN STACK-CFM=  0.2378E 05

                              FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 12.41
FAN DISCHARGE PRESS. STATIC= 9.625  VEL. HEAD= 4.975  TOTAL HEAD=14.600
STATIC PRESS. COR.=     10.423  TOTAL PRESS. COR.=     15.398
FAN PRESS INCREASE=14.850  FAN FLOW CFM=  0.2562E 05  FAN HORSEPOWER=  0.5994E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2470E 05

                              APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1640E 04
OIL COOLER FLOW CFM=  0.1177E 05   VEL. FT/SEC=  0.1090E 03

                              SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  9.75   PORT= 10.05    AVG=  9.90
DONALDSON PRESS. DROP, STB=  0.85    PORT=  1.55    AVG=  1.20
PEERLESS PRESS. DROP,  STB=  0.90    PORT=  0.50    AVG =  0.70
PRESS DROP TO ENG.,  STB=  0.35    PORT=  0.78    AVG=  0.56
PLENUM PRESS.,  PORT=      7.650  STBD=      7.225  AVG=      7.437
SCAV. PRESS. DROP=      3.900
OIL COOLER DUCT DROP=      3.000
DUCT TO HOT COMP. DROP=      0.0
DUCT TO OIL COOLER DROP=      5.300
```

14

TEST No. 4 C2A0615

```
                              INPUT DATA
N2=  95.000  94.500  94.200  95.000
 TOP    20.000  22.000  19.000  20.000
STACK VEL. HD.=     1.00    1.00    0.80    1.00    1.00    0.90    0.95    1.10    1.00
STACK STATIC HD.=    -1.10   -1.50   -1.20   -1.00   -1.10   -1.00   -0.90   -1.00   -1.00
FAN VEL. HD.=        7.900    5.000   6.300  10.000
FAN STATIC HEAD=         6.500    8.500    7.000    7.000
PRESS. AT DONALDSON-STBD          8.200    7.000    9.500    6.200
PRESS. AT DONALDSON-PORT=            5.500    8.500    7.700    9.000
OIL COOLER VEL. HD.= 4.800     OIL COOLER STATIC= 3.500
PEERLESS PRESS-STBD= 5.200     PORT= 5.000
PRESS AFT OF PEERLESS-STBD= 3.200      PORT= 3.500
ENGINE PLENUM PRESS-STBD=      1.20     0.40     0.50     1.40
ENGINE PLENUM PRESS-PORT=    -1.00    -0.50    -0.50    -1.00
SCAV.  EXH. PRESS=       2.000  HOT SECT. PRESS.=       2.500  COOLER PRESS=      0.200
OUTSIDE AIR TEMP.=  72.500
STACK TEMPS. =         76.000      77.000      79.000      79.000
FAN DISCHARGE TEMP.= 83.000
ENGINE PLENUM AIR TEMP.=    85.00  129.00

                              ENGINE PREFORMANCE
TEMP=   85.00    ADJ. HP=      0.6473E 03TEMP=  129.00     ADJ. HP=     0.6227E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.6634E 03
ENGINE AIR(BOTH SIDES)-CFM=  0.1708E 05  TAVG(3&4)= 107.000

                              STACK PERFORMANCE
AVG STACK TEMP=       77.75     TEMP RISE IN STACK        5.25
STACK PRESSURES  VEL= 0.979   STATIC=-1.092  TOTAL HEAD=-0.112
FLOW IN STACK-CFM=  0.2669E 05

                              FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 11.34
FAN DISCHARGE PRESS. STATIC= 7.250  VEL. HEAD= 7.300  TOTAL HEAD=14.550
STATIC PRESS. COR.=      7.512  TOTAL PRESS. COR.=    14.812
FAN PRESS INCREASE=14.662  FAN FLOW CFM=  0.3076E 05  FAN HORSEPOWER=  0.7107E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2872E 05

                              APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1559E 04
OIL COOLER FLOW CFM=  0.1601E 05    VEL. FT/SEC=  0.1482E 03

                              SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  7.72    PORT=  7.67    AVG=  7.70
DONALDSON PRESS. DROP, STB=  2.52    PORT=  2.67     AVG=  2.60
PEERLESS PRESS. DROP,  STB=  2.00    PORT=  1.50     AVG =  1.75
PRESS DROP TO ENG.,  STB=  2.32    PORT=  4.25     AVG=  3.29
PLENUM PRESS.,  PORT=       0.875  STBD=      -0.750  AVG=       0.062
SCAV. PRESS. DROP=           3.000
OIL COOLER DUCT DROP=      1.500
DUCT TO HOT COMP. DROP=       1.000
DUCT TO OIL COOLER DROP=        3.300
```

15

TEST No. 5 C2A0615-1

```
                                    INPUT DATA
N2=  70.000  69.900  69.900  70.200
 TOP     8.000  12.000  10.000  10.000
STACK VEL. HD.=     1.00     0.80     0.78     1.10     1.00     1.15     1.00     1.05     1.00
STACK STATIC HD.=   -1.50    -1.60    -1.50    -1.00    -1.30    -1.20    -1.00    -1.20    -1.00
FAN VEL. HD.=        8.000   3.800   6.900  10.000
FAN STATIC HEAD=       8.000   9.000   8.500   8.500
PRESS. AT DONALDSON-STBD      10.000   7.500  11.300   7.500
PRESS. AT DONALDSON-PORT=      7.800   9.700   9.100  10.300
OIL COOLER VEL. HD.= 1.500    OIL COOLER STATIC= 4.500
PEERLESS PRESS-STBD= 7.100    PORT= 6.800
PRESS AFT OF PEERLESS-STBD= 5.800     PORT= 5.500
ENGINE PLENUM PRESS-STBD=     5.00    4.20    3.60    3.00
ENGINE PLENUM PRESS-PORT=     3.20    4.00    3.60    3.00
SCAV.  EXH. PRESS=     3.300  HOT SECT. PRESS.=    3.600  COOLER PRESS=      0.200
OUTSIDE AIR TEMP.=  84.000
STACK TEMPS. =      87.000    84.000    86.000    87.000
FAN DISCHARGE TEMP.=  95.000
ENGINE PLENUM AIR TEMP.=    94.00  137.00

                                    ENGINE PREFORMANCE
TEMP=   94.00    ADJ. HP=    0.2344E 03TEMP=  137.00    ADJ. HP=    0.2258E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.2422E 03
ENGINE AIR(BOTH SIDES)-CFM=  0.1445E 05  TAVG(3&4)= 115.500

                                    STACK PERFORMANCE
AVG STACK TEMP=       86.00     TEMP RISE IN STACK          2.00
STACK PRESSURES  VEL= 0.990   STATIC=-1.317  TOTAL HEAD=-0.327
FLOW IN STACK-CFM=  0.2702E 05

                                    FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 12.52
FAN DISCHARGE PRESS. STATIC= 8.500  VEL. HEAD= 7.175  TOTAL HEAD=15.675
STATIC PRESS. COR.=     8.942  TOTAL PRESS. COR.=    16.117
FAN PRESS INCREASE=16.002  FAN FLOW CFM=  0.3056E 05  FAN HORSEPOWER=  0.7705E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2879E 05

                                    APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1584E 04
OIL COOLER FLOW CFM=  0.9046E 04    VEL. FT/SEC=  0.8376E 02

                                    SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  9.07   PORT=  9.22   AVG=  9.15
DONALDSON PRESS. DROP, STB=  1.97   PORT=  2.42   AVG=  2.20
PEERLESS PRESS. DROP,  STB=  1.30   PORT=  1.30   AVG =  1.30
PRESS DROP TO ENG.,  STB=  1.85   PORT=  2.05   AVG=  1.95
PLENUM PRESS.,  PORT=     3.950  STBD=     3.450  AVG=     3.700
SCAV. PRESS. DROP=    3.500
OIL COOLER DUCT DROP=     2.300
DUCT TO HOT COMP. DROP=      0.900
DUCT TO OIL COOLER DROP=     4.300
```

16

TEST No. 5 C2A0615-2

```
                                          INPUT DATA
N2=  85.100  85.000  84.500  85.200
 TOP     15.000  17.000  14.000  15.000
STACK VEL. HD.=       1.10      0.95     0.80      1.15      1.05      1.10      1.05      1.10      0.80
STACK STATIC HD.=    -1.30     -1.50    -1.30     -1.20     -1.30     -1.00     -1.00     -1.10     -1.00
FAN VEL. HD.=        8.400    4.400    7.100     5.200
FAN STATIC HEAD=         8.000     8.500     7.500     7.500
PRESS. AT DONALDSON-STBD           9.000     7.000    10.500     7.000
PRESS. AT DONALDSON-PORT=            6.000     9.200     8.500    10.000
OIL COOLER VEL. HD.= 1.600     OIL COOLER STATIC= 4.000
PEERLESS PRESS-STBD= 6.100     PORT= 5.800
PRESS AFT OF PEERLESS-STBD= 4.400      PORT= 7.800
ENGINE PLENUM PRESS-STBD=   3.10      2.30      1.70      0.70
ENGINE PLENUM PRESS-PORT=   1.00      2.00      1.90      0.50
SCAV.  EXH. PRESS=       2.900   HOT SECT. PRESS.=       3.200   COOLER PRESS=       0.200
OUTSIDE AIR TEMP.=  84.000
STACK TEMPS. =     83.000     83.000     85.000     88.000
FAN DISCHARGE TEMP.=  91.000
ENGINE PLENUM AIR TEMP.=    93.00  130.00

                                          ENGINE PREFORMANCE
TEMP=    93.00     ADJ. HP=     0.4343E 03TEMP=  130.00     ADJ. HP=     0.4204E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--   0.4483E 03
ENGINE AIR(BOTH SIDES)-CFM=  0.1597E 05   TAVG(3&4)= 111.500

                                          STACK PERFORMANCE
AVG STACK TEMP=        84.75     TEMP RISE IN STACK          0.75
STACK PRESSURES   VEL= 1.033    STATIC=-1.217   TOTAL HEAD=-0.183
FLOW IN STACK-CFM=  0.2757E 05

                                          FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 11.39
FAN DISCHARGE PRESS. STATIC= 7.875   VEL. HEAD= 6.275   TOTAL HEAD=14.150
STATIC PRESS. COR.=        8.266   TOTAL PRESS. COR.=      14.541
FAN PRESS INCREASE=14.333   FAN FLOW CFM=   0.2871E 05   FAN HORSEPOWER=   0.6485E 02
AVG. OF STACK AND FAN FLOW-CFM=   0.2814E 05

                                          APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =   0.1593E 04
OIL COOLER FLOW CFM=   0.9309E 04    VEL. FT/SEC=   0.8619E 02

                                          SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=   8.37    PORT=   8.42    AVG=   8.40
DONALDSON PRESS. DROP,  STB=   2.28    PORT=  2.62       AVG=   2.45
PEERLESS PRESS. DROP,   STB=   1.70    PORT= -2.00       AVG = -0.15
PRESS DROP TO ENG.,    STB=  2.45    PORT=   6.45      AVG=  4.45
PLENUM PRESS.,    PORT=     1.950   STBD=       1.350   AVG=       1.650
SCAV. PRESS. DROP=        2.900
OIL COOLER DUCT DROP=        1.900
DUCT TO HOT COMP. DROP=        0.800
DUCT TO OIL COOLER DROP=        3.800
```

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```
                              INPUT DATA
N2=  96.200  95.000  94.700  95.300
 TOP    20.000  22.000  18.000  19.000
STACK VEL. HD.=     1.10      0.95      0.82      1.10      1.05      1.00      1.05      1.20      1.05
STACK STATIC HD.=   -1.30     -1.50     -1.30     -1.20     -1.30     -1.00     -1.00     -1.10     -1.00
FAN VEL. HD.=      8.500    4.600    7.100    5.200
FAN STATIC HEAD=      6.800    8.000    7.000    7.000
PRESS. AT DONALOSON-STBD        8.500    6.400   10.000    6.200
PRESS. AT DONALDSON-PORT=        6.000    8.600    8.000    9.200
OIL COOLER VEL. HD.= 1.400      OIL COOLER STATIC= 3.500
PEERLESS PRESS-STBD= 5.200      PORT= 5.200
PRESS AFT OF PEERLESS-STBD= 3.100    PORT= 3.000
ENGINE PLENUM PRESS-STBD=    1.60      0.40      0.0      -1.20
ENGINE PLENUM PRESS-PORT=    -0.80      0.80     -0.20     -1.00
SCAV.  EXH. PRESS=      2.000   HOT SECT. PRESS.=       3.000   COOLER PRESS=       0.100
OUTSIDE AIR TEMP.=   84.000
STACK TEMPS. =   83.000     83.000   84.000     84.000
FAN DISCHARGE TEMP.=    90.000
ENGINE PLENUM AIR TEMP.=    92.00  135.00

                              ENGINE PREFORMANCE
TEMP=    92.00      ADJ. HP=      0.6315E 03TEMP=  135.00      ADJ. HP=      0.6082E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--   0.6513E 03
ENGINE AIR(BOTH SIDES)-CFM=   0.1710E 05   TAVG(3&4)= 113.500

                              STACK PERFORMANCE
AVG STACK TEMP=        83.50      TEMP RISE IN STACK          -0.50
STACK PRESSURES   VEL= 1.052   STATIC=-1.217   TOTAL HEAD=-0.165
FLOW IN STACK-CFM=   0.2780E 05

                              FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 10.76
FAN DISCHARGE PRESS. STATIC= 7.200   VEL. HEAD= 6.350   TOTAL HEAD=13.550
STATIC PRESS. COR.=      7.540   TOTAL PRESS. COR.=      13.890
FAN PRESS INCREASE=13.715   FAN FLOW CFM=   0.2887E 05   FAN HORSEPOWER=   0.6238E 02
AVG. OF STACK AND FAN FLOW-CFM=   0.2833E 05

                              APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =   0.1595E 04
OIL COOLER FLOW CFM=   0.8700E 04    VEL. FT/SEC=   0.8055E 02

                              SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  7.77    PORT=  7.95   AVG=  7.86
DONALDSON PRESS. DROP, STB=   2.57     PORT=   2.75     AVG=   2.66
PEERLESS PRESS. DROP,  STB=  2.10     PORT=  2.20     AVG =   2.15
PRESS DROP TO ENG.,   STB=  2.90    PORT=   3.30    AVG=  3.10
PLENUM PRESS.,   PORT=        0.200   STBD=    -0.300   AVG=     -0.050
SCAV. PRESS. DROP=     3.200
OIL COOLER DUCT DROP=    1.700
DUCT TO HOT COMP. DROP=       0.500
DUCT TO OIL COOLER DROP=      3.400
```

TEST No.5 C2A0615-3

Test No. 6 C3A0616

```
                                 INPUT DATA
N2=  95.200  95.000  94.300  95.200
 TOP    20.000  22.000  19.000  20.000
STACK VEL. HD.=      1.10     1.00     0.83     1.20     1.30     1.05     0.95     0.95     0.95
STACK STATIC HD.=     -1.50    -1.60    -1.00    -1.00    -1.00    -1.00    -0.80    -1.30    -1.20
FAN VEL. HD.=        8.200    5.000   6.900    5.300
FAN STATIC HEAD=         7.000    8.400    7.500    7.500
PRESS. AT DONALDSON-STBD        9.000    6.700  10.200    7.600
PRESS. AT DONALDSON-PORT=        6.000    9.000    7.900    9.500
OIL COOLER VEL. HD.= 1.300    OIL COOLER STATIC= 4.000
PEERLESS PRESS-STBD= 5.590     PORT= 5.300
PRESS AFT OF PEERLESS-STBD= 3.300      PORT= 2.000
ENGINE PLENUM PRESS-STBD=     3.00     0.80     0.20    -1.10
ENGINE PLENUM PRESS-PORT=    -0.50     1.00    -0.20    -0.80
SCAV.  EXH. PRESS=        8.500  HOT SECT. PRESS.=     3.000  COOLER PRESS=      0.200
OUTSIDE AIR TEMP.=  81.000
STACK TEMPS. =        74.000     73.000     77.000     78.000
FAN DISCHARGE TEMP.=  84.000
ENGINE PLENUM AIR TEMP.=   83.00  118.00

                                 ENGINE PREFORMANCE
TEMP=    83.00     ADJ. HP=      0.6503E 03TEMP=  118.00     ADJ. HP=     0.6303E 03
AVERAVGE HORSEPOWER--BOTH ENGINES--  0.6652E 03
ENGINE AIR(BOTH SIDES)-CFM=  0.1701E 05  TAVG(3&4)= 100.500

                                 STACK PERFORMANCE
AVG STACK TEMP=        75.50     TEMP RISE IN STACK          -5.50
STACK PRESSURES   VEL= 1.052   STATIC=-1.242  TOTAL HEAD=-0.189
FLOW IN STACK-CFM=  0.2758E 05

                                 FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 11.16
FAN DISCHARGE PRESS. STATIC= 7.600   VEL. HEAD= 6.350  TOTAL HEAD=13.950
STATIC PRESS. COR.=      7.842  TOTAL PRESS. COR.=      14.192
FAN PRESS INCREASE=14.139  FAN FLOW CFM=  0.2872E 05  FAN HORSEPOWER=  0.6399E 02
AVG. OF STACK AND FAN FLOW-CFM=  0.2815E 05

                                 APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =  0.1574E 04
OIL COOLER FLOW CFM=  0.8337E 04    VEL. FT/SEC=  0.7720E 02

                                 SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=  8.37    PORT=   8.10    AVG=  8.24
DONALDSON PRESS. DROP, STB=  2.87     PORT=  2.80     AVG=  2.84
PEERLESS PRESS. DROP,   STB=  2.20     PORT=  3.30     AVG =  2.75
PRESS DROP TO ENG.,   STB=  2.57    PORT=  2.12     AVG=  2.35
PLENUM PRESS.,  PORT=         0.725  STBD=      -0.125  AVG=       0.300
SCAV. PRESS. DROP=     -3.200
OIL COOLER DUCT DROP=         1.300
DUCT TO HOT COMP. DROP=          1.000
DUCT TO OIL COOLER DROP=         3.800
```

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TEST No. 6 C3B0616

```
                          INPUT DATA
N2=  92.500  92.300  93.700  94.000
 TOP    42.000  43.000  44.000  46.000
STACK VEL. HD.=     1.50     0.80     0.50     1.40     1.65     1.60     1.65     1.60     1.50
STACK STATIC HD.=   -0.20    -0.80    -0.80    -0.60    -0.50    -0.50     0.0     -0.50     0.0
FAN VEL. HD.=       8.800    6.700   7.200    5.000
FAN STATIC HEAD=       6.000    7.500   7.000    7.000
PRESS. AT DONALDSON-STBD          8.500    5.400    9.000    5.500
PRESS. AT DONALDSON-PORT=         5.000    8.000    7.500    8.000
OIL COOLER VEL. HD.= 1.000     OIL COOLER STATIC= 3.500
PEERLESS PRESS-STBD= 4.200     PORT= 4.000
PRESS AFT OF PEERLESS-STBD= 1.000     PORT= 0.800
ENGINE PLENUM PRESS-STBD=  -4.00    -3.00    -2.20    -4.00
ENGINE PLENUM PRESS-PORT=  -2.00    -2.60    -2.60    -3.00
SCAV.  EXH. PRESS=      1.500  HOT SECT. PRESS.=       2.700  COOLER PRESS=      1.500
OUTSIDE AIR TEMP.=  81.000
STACK TEMPS. =        74.000      72.000      80.000      80.000
FAN DISCHARGE TEMP.=  85.000
ENGINE PLENUM AIR TEMP.=    84.00    78.00

                          ENGINE PREFORMANCE
TEMP=    84.00     ADJ. HP=     0.1377E 04TEMP=    78.00     ADJ. HP=     0.1385E 04
AVERAVGE HORSEPOWER--BOTH ENGINES--   0.1410E 04
ENGINE AIR(BOTH SIDES)-CFM=   0.1970E 05   TAVG(3&4)=   81.000

                          STACK PERFORMANCE
AVG STACK TEMP=        76.50     TEMP RISE IN STACK          -4.50
STACK PRESSURES   VEL= 1.392   STATIC=-0.375   TOTAL HEAD= 1.017
FLOW IN STACK-CFM=   0.3147E 05

                          FAN PERFORMANCE
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.) = 10.75
FAN DISCHARGE PRESS. STATIC= 6.875   VEL. HEAD= 6.925   TOTAL HEAD=13.800
STATIC PRESS. COR.=        7.107   TOTAL PRESS. COR.=       14.032
FAN PRESS INCREASE=12.783   FAN FLOW CFM=   0.3002E 05   FAN HORSEPOWER=   0.6048E 02
AVG. OF STACK AND FAN FLOW-CFM=   0.3074E 05

                          APU AND OIL COOLER FLOWS
APU AIR FLOW, CFM =   0.1584E 04
OIL COOLER FLOW CFM=   0.7319E 04    VEL. FT/SEC=   0.6777E 02

                          SYSTEM PRESSURE DROPS
PRESS. AT DONALSON, STB=   7.10    PORT=   7.12    AVG=   7.11
DONALDSON PRESS. DROP, STB=   2.90     PORT=   3.13     AVG=   3.01
PEERLESS PRESS. DROP,   STB=   3.20     PORT=   3.20     AVG =   3.20
PRESS DROP TO ENG.,   STB=   4.30    PORT=   3.35    AVG=   3.82
PLENUM PRESS.,   PORT=     -3.300   STBD=     -2.550   AVG=     -2.925
SCAV. PRESS. DROP=       2.500
OIL COOLER DUCT DROP=         0.500
DUCT TO HOT COMP. DROP=         0.800
DUCT TO OIL COOLER DROP=         2.000
```

APPENDIX B

PREDICTION OF AMS PERFORMANCE WITH THE PROPOSED MODIFICATIONS

INTRODUCTION

Four major changes in the LACV-30 Air Management System are contemplated: incorporation of a diffuser at the fan exit, incorporation of a third stage of filtration, enlargment of the entrance to the engine inlet compartment, and removal of the oil cooler airload. An estimate has been made of the performance which can be expected. The method involves the determinations of a pressure loss coefficient, k, for each component of the system. The coefficient is defined by:

$$k = \Delta P/Q^n$$

where ΔP is the pressure drop across the element under scrutiny, Q is the volumetric flow rate, and n is an exponent defined by the mode of flow. In nearly all cases the flow is turbulent and $n = 2.0$. One exception occurs with the proposed barrier filter (Donaldson Duralife II), for which the manufacturer's data indicates that $n = 1.4$. For all components installed during the test program the loss coefficient k was determined from test data. For untested components, estimates were made from design data. The loss coefficients are identified by a two-digit subscript which is keyed to the system block diagram in Figure B-1. Flows are in CFM, pressure drop in inches, w.g.

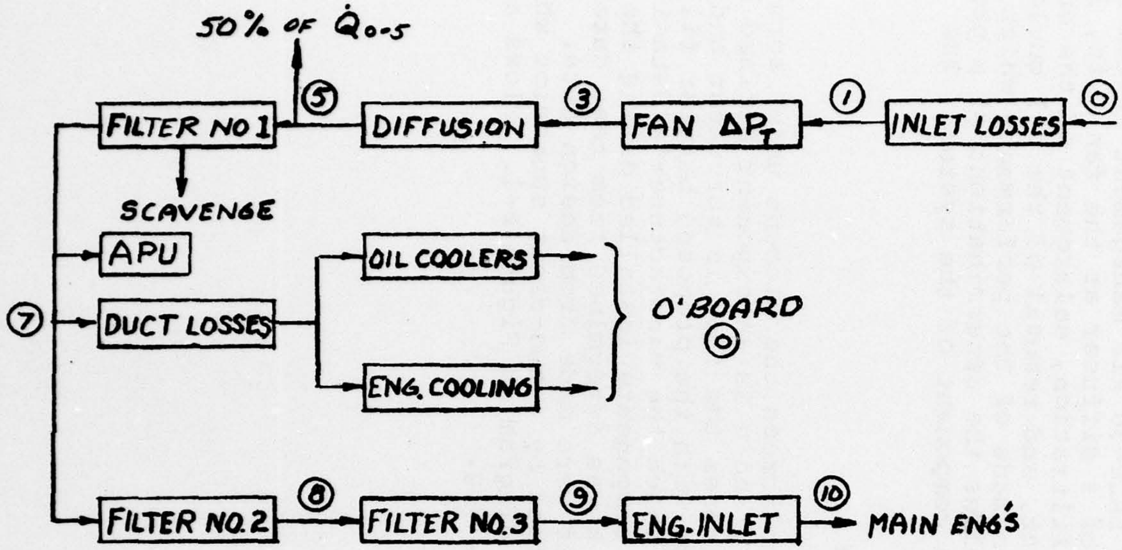

FIG B-1. BLOCK DIAGRAM OF AIR MANAGEMENT SYSTEM OF THE LACV-30 DURING PHASE I TESTS

NOTE: PROPOSED MODIFICATION WILL ELIMINATE COOLING SYSTEM BETWEEN STATIONS 7 & 0

FIG. B-1

DEVELOPMENT

ΔP_{0-1}. The nine pitostatic measurements made in the inlet stack defined a coefficient for the inlet. Direct measurements for the inlet elbow were not provided for, so that a loss factor was developed for a Reynolds number of 1.5×10^6 and a radius ratio of 0.7 using Reference 1. The sum of the two inlet coefficients yields:

$$\Delta P_{0-1} = -1.83 \times 10^{-9} \, Q_F^{\,2}$$

ΔP_{1-3}. This is the fan performance capability, and is taken from manufacturer's data, Figure 6, with corrections for the installation differences between the manufacturer basis for quotation and the LACV-30 system.

ΔP_{3-5}. The losses between these stations is the sum of the loss in the diffuser and the loss involved due to the abrupt discharge of the flow from the diffuser exit to the receiver. From diffuser design data from Reference 2, the recovery for the two concentric parts of the diffuser will be 56% of the inlet kinetic head, and for the uncontrolled turbulent diffusion downstream a recovery of 25% of the diffuser discharge head is assumed. Combining these results in an overall loss equation of:

$$\Delta P_{3-5} = -0.292 \times 10^{-8} \, Q_F^{\,2}$$

ΔP_{5-7}. From test data and using one-half of the fan flow rate, Q_F (because the fan flow is divided at this point),gives:

$$\Delta P_{5-7} = -1.452 \times 10^{-8} \left[Q_F/2\right]^2$$

ΔP_{7-8}. The flow through the demister, Filter No. 2, Q_E, is established by the engines. No direct mass rate measurement was provided for, but from the power measurement (speed and torque) the air rate can be deduced from the engine manufacturer's data, Reference 3, With appropriate corrections for engine operating conditions, the equation becomes:

$$\Delta P_{7-8} = -2.93 \times 10^{-8} \, Q_E^{\,2}$$

ΔP_{8-9}. Filter No. 3 is a Donaldson Duralife II Barrier filter untested by Bell. From the manufacturer's data it appears that the

flow through these elements is partially laminar, so that the loss equation is deduced to be:

$$\Delta P_{8-9} = -3.78 \times 10^{-6} \ Q_E^{1.4}$$

ΔP_{9-10}. A loss coefficient was determined for the existing engine inlet, the area of which is 218 in^2. This is applied directly to the enlarged inlet 387 in^2, now planned:

$$\Delta P_{9-10} = -1.25 \times 10^{-8} \ Q_E^{2}$$

It is probable that this coefficient is slightly pessimistic.

Applications of Loss Factors

For the modified system, supplying no cooling air, assume the the engines are operated at normal power, 1440 HP, and that the ambient conditions are standard, Pamb = 2116 PSFA
Tamb = $518.7^{\circ}R$

Using the coefficients developed in the preceding section, the method for predicting the system performance and the end result follow: To develop the system airflow, first the engine air rates are determined from References 3 and 4:

Main Engines = Q_E = 9,930 cfm (per side)

APU Engine 1/2 Q_S = 840 cfm (per side)

Total 10,770 cfm

Assuming that the scavenging air rate from Filter No. 1 is the 10% required for effective operation, the flow into both of the filters No. 1 is:

$$Q_F = 2\ (10,770)/0.9 = 23,930$$

$$\Delta P_{0-1} = -1.183 \times 10^{-9}\ (23,930)^2 = 23,930$$

ΔP_{1-3} @ 23,930 cfm = +17.1 (fan data)

$$\Delta P_{3-5} = 0.292 \times 10^{-8}\ (23,930)^2 = -1.67$$

$$Q_{5-7} = 0.5\ (23,930) = 11,965$$

$$\Delta P_{5-7} = 1.452 \times 10^{-8}\ (11,965)^2 = -2.08$$

$$Q_{7-8} = 9{,}930 \text{ (engine air rate)}$$

$$\Delta P_{7-8} = -2.93 \times 10^{-8} (9{,}930)^2 = -2.89$$

$$\Delta P_{8-9} = -3.78 \times 10^{-6} (9{,}930)^{1.4} = -1.47$$

$$\Delta P_{9-10} = -1.25 \times 10^{-8} (9{,}930)^2 = -1.23$$

$$\Delta P_{10} \text{ (Eng Inlet)} = +7.06$$